HYDRAULIC, STEAM, AND HAND POWER

LIFTING AND PRESSING MACHINERY.

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The author fears, owing to the want of time at his disposal, that the work is not in such a perfect form as he would have wished; he, however, trusts all shortcomings in this respect will meet with lenient judgment from his readers.

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PART I.

HYDRAULIC LIFTING MACHINERY.

CHAPTER I.

HYDRAULIC HIGH-PRESSURE LIFTING MACHINERY.

THE first practical use of water for the transmission of force was made by Bramah, in the hydraulic press of which he was the inventor; it was patented in 1796. He also intended to use the same system as a motive power for cranes, etc. For transmitting power to great distances, water is the most suitable, and in the end, most economical; it possesses many advantages over other plans, of which the author treats in another place.

The hydraulic system, as applied to cranes and other lifting apparatus, was first brought into extensive use by Sir W. G. Armstrong, to whom the author wishes to bear full testimony as the "pioneer" of most of the work done since in this branch of engineering. From the success which attended his first efforts in this way, in 1846, may be traced the researches of others in the same line, and the execution of most important and successful works.

The author does not intend here to go closely into the question as to the relative cost of lifting by hydraulic power, as compared with other plans; he will add a few remarks as to this at the end of this section of the book (see p. 33).

The useful effect obtained from direct-acting hydraulic apparatus is about 93 per cent., and when short-stroke cylinders, combined with movable pulleys, are used, it varies from

60 per cent. (at 10 to 1) to 75 per cent. (at 4 to 1);—this is assuming the machinery to be of the best kind.

In most of the large docks in London and elsewhere, hydraulic quay cranes are usually fixed; portable cranes, however, are coming into use in many places. The circumstances of the work to be done, and arrangement of the place must decide which is the most suitable plan. There is no difficulty in connecting the water pressure from the main pipes to the cranes.

Machinery for this class of work will now be described in detail. The engines for pumping the water, and the boilers to supply steam for same, are the first consideration. These are usually placed at a convenient spot,—where possible, about midway between the work to be done; this, however, is not of great moment, because, in the case of docks, to satisfy the fire insurance companies, and reduce the amount of the premiums on the policies, the engine and boiler houses are often placed outside the dock, the mains being carried a considerable distance from the engines and pumps. Special arrangements are necessary as to accumulators and valves, which are described in another place.

The application of hydraulic machinery is a large and most important subject; the author has hereafter fully treated most of the apparatus in general use. If more detail is mentioned than seems necessary to practical men, the excuse is, so little appears to be known by many engineers, architects, and users of this class of machinery, that it is hoped the details given in this book may be some guide to them in laying out such plant, and will help to show where it can be usefully employed.

Water Pressure.

To obtain the requisite pressure in the pipes for working the hydraulic apparatus, several means have been employed which are detailed below.

1. Head of Water from a Tank.—The water is pumped up by engine power to a tank fixed on a tower of brickwork, in some cases 200 feet high, and mains carried from it to distribute the pressure. The most notable instance of this is the one still existing at the Great Grimsby Docks. The tower in this case carries a wrought-iron tank, holding 33,000 gallons

of water at 200 feet from the ground line; the size of the top of the tower is 26 feet square and 28 feet at base, walls 4 feet thick at base, and 3 feet thick at the tank level; supply pipe is 13 inches diameter.

Owing to the great cost of such apparatus, especially as regards the foundation, for *high-pressure* work, this plan is seldom used. It has, however, one advantage over the other plans: the tank forms a large reservoir of power, and allows the cranes to be used for a certain period independent of the engines, and consequent attendance of the men in charge of the same.

2. Air vessels were next tried, but the difficulty in keeping them properly charged with air and retaining the pressure was so great that this plan has been generally superseded by the apparatus described in the next chapter. It must be borne in mind that these remarks only apply to *high-pressure* work, as air vessels are still advantageously used for pressure up to 200 lbs. on the square inch; and, in places where accumulators are too costly and would take up too much space, they are to be recommended.

A small air pump should be employed to keep up a steady supply of air, and thus maintain the proper working pressure in the pipes.

The air vessel should be well made and double rivetted, and of ample size for the work. The pumping power should also be large, to be equal to any sudden demand upon the apparatus. The author prefers to make the air vessels small in diameter and high, in preference to a larger diameter and less height, as he believes the air is not so quickly absorbed on this plan by the water, and in this way less trouble is caused in keeping up the pressure in the pipes.

CHAPTER II.

ACCUMULATORS.

THE water pressure for working cranes, etc., is usually given by the above apparatus, which consists of a loaded ram working in a cylinder, similar to a hydraulic press. The top of the ram carries a cage loaded with stone or other material, to give a dead load direct on the same; this counter-balance cage rises and falls between two iron guides fixed to strong timbers. Water is pumped into the cylinder until the required pressure is obtained; this varies from 300 to 750 lbs. per square inch, the latter being considered the most suitable for working cranes and hoists, etc. The cylinders and rams for the above pressure are made of thick metal, to stand heavy shocks.

In the accumulators first made, the cage containing the load rose and fell *above* the cylinder; but the more modern ones are made with a hole in the centre of the cases, allowing them to work *over* the cylinder, as shown in No. 1 Drawing.

Base plates for the cylinder must have powerful ribs, and be well bedded on a sound foundation; the base plate should be cast separate from the cylinder, to ensure sound castings in both cases, and also to facilitate fixing.

The cage, or round case for the counter-balance, is made of wrought iron, ¼ to ⅜ of an inch thick, with stay rods to take weight of same fixed to a cast-iron cross-head fitted to the head of the ram.

Self-acting gear is fixed to the top of cage to regulate, by means of the throttle valve, the speed of the engines to suit the work. Safety valves are fitted to the pipes, to give relief in case of sudden stoppage. *Self-acting air valves* are also provided to avoid shocks.

The action of the "accumulator" is thus:—At the commencement of the pumping all the pipes are filled, then the

pipe leading to the accumulator cylinder being on the main pipe, the loaded ram is raised; if no crane, etc., is wanted at the time, the engines are stopped when the ram is full up. All the pipes are now charged to the full working pressure; directly, however, pressure is required from the pipes, by using any crane, the ram falls and the valves of the engines are again opened by the self-acting gear, and the pumping is recommenced, so keeping up the required amount of pressure. The area of the ram and stroke depends upon the class of work; as a rule, not more than the contents of three crane cylinders are allowed. The pumps and engine power should be sufficient for the largest demand that can be made in any emergency.

The distance from the accumulator to the cranes is not a matter of much moment; but where the pipes have many bends and follow a circuitous route, extra accumulators are usually fixed at various points. This specially applies when the work is done at a dock or wharf, and where the cranes are a long distance apart.

THE PIPES used are cast iron, 2, 3, 4, and 6 inches diameter, $\frac{7}{8}$ to $1\frac{1}{4}$ inch thick, with faced joints, and two lugs to the flanges; safety valves are fitted at various points, and means taken to protect the pipes from frost.

The useful effect of the "accumulator" is about 75 to 80 per cent. The wear and tear is very small, and the consequent repairs almost *nil*.

ENGINES FOR PUMPING.

The engines usually employed are high-pressure of the horizontal class, coupled with one fly-wheel (see Drawing No. 2). The pumps are worked direct off the cross-head; they have rams and pistons, and are double-acting; the valves are india-rubber, with steel intermediate discs; and only very small lift is given to them. The valve-boxes are arranged to be easily accessible, and each pump is provided with a safety valve,—in case of any sudden shock this prevents a fracture. The engines are controlled by the self-acting gear before named, worked by the accumulator.

The fly-wheel should be heavy, turned on the rim, and well balanced.

Foundations must be very good, and a sound bottom obtained, to keep the engine from vibration.

The speed of the engines vary from a few strokes per minute to 300 feet per minute.

The best kind of engines are high pressure worked expansively; all other types are too complicated, and likely to get out of order. The engines should be strongly made, and of ample power compared to the work to be done.

The engines sometimes have the pumps fixed at the back of the cylinders; they take up rather more space, but some advantage is gained by the facility with which the valves and all working parts can be got at without going under the floor of the engine-room. This is a matter of detail, and does not affect the system of working.

THE BOILERS are of the Cornish or Lancashire type, and should be placed in a house near, so that the same man who attends the engine can also superintend the stokers in the boiler-house. The boiler should be of ample capacity to meet any unusual demand upon the engines.

Water used.—In the case of docks, most of the water is returned to the dock; but in smaller places it is used over again, so there need be but little waste. It is very important to keep the water clean and free from grit and dirt. All tanks should be covered, and cleaned out at stated periods.

CHAPTER III.

HYDRAULIC CRANES.

CRANES for dock and wharf work are usually constructed as shown in Drawing No. 3. Taking a two-ton crane as a type, the posts are of cast iron, fixed to a base plate; the jib works round on the turned head and base of same; it is of wrought iron, formed either like a rivetted girder, or two slabs, strutted apart by cast-iron distance pieces or wrought-iron bracings, to keep them from "raking."

The top wheel is 18 inches in diameter by 3 inches wide, with a plain groove for the chain to work in; and in order to reduce the friction, the groove should be turned.

WORKING CYLINDERS (see Drawing No. 4).—The cranes are worked by cylinders fixed horizontally under the quay or jetty, with rams working through stuffing boxes or leather packing; the diameter of rams and the stroke depend upon the weight and height lifted.

To the head of ram is fixed a carriage with movable pulleys. The chain is attached to the base of the cylinder, then passes over the movable and fixed pulleys, giving the necessary length of chain for the height to be lifted.

To swing the crane two separate cylinders are used, having chains passing from the ram-heads to a grooved wheel keyed upon the jib-post, near the bottom. The cranes are worked by two valve boxes and two sets of valves—one to control the raising and lowering, the other the "swinging." Air valves and safety valves are provided to each crane, to take any sudden shock and so prevent fracture.

At some wharves the cylinders cannot be sunk below the ground line; in this case the jib is fixed upon a platform, and

the cylinders below. This has the additional advantage that the jib is kept clear of the sides of the vessel when the level of the water rises.

For small weights and low lifts, the cylinders are fixed in the hollow part of the crane post. The same arrangements are made as before as to the stroke of the cylinders compared to the height to be lifted.

In cases where craft have to be unloaded from a V-shaped "jetty" some distance from the front of the warehouse, a special jib is fixed in framing, and at a sufficient height to keep the floor of jetty clear to land the goods; the jibs in these cases are from 25 to 30 feet radius, and sometimes more.

Wharf cranes are usually made to carry 35 to 40 hundred-weight, and for exceptional weights one or more cranes are fixed, capable of lifting up to 5 tons, fitted with two lifting cylinders when not wanted for such heavy weights. One lifting cylinder only is used for the lighter weights, and so loss of power is saved, or where the business is large these cranes are only used for the heavy weights.

For cranes to lift above 10 tons, it is advisable to apply auxiliary hand power to enable these occasional weights to be raised. The strength of all the various parts being made sufficient to take the maximum load, a movable block is used in such cases.

Hydraulic Crane, 160 Tons.

A very fine crane is shown in Drawing No. 5. It was made and erected by Sir W. G. Armstrong and Co., to load heavy guns, etc. The lifting power is a suspended cylinder from the crane-head, with ram and piston working in same. The lift is made direct from the ram, and not by means of chains or gear. The swinging gear does not much differ from the usual plan.

The jib and all its parts are wrought iron, very powerful and carefully proportioned. Such a crane is of necessity only used for heavy and special lifts; the action is very slow, to avoid any undue strain. The height lifted is about 40 feet. The author believes this crane, and one at the Elswick Works, are the only two examples yet erected, and in his opinion the only safe method of dealing with such heavy weights. They

are of necessity very costly, but as they have to deal with goods of great value, such apparatus are true economy in the end.

It need hardly be added the foundations must be carefully made, massive, and resting on a sound bottom. Where the ground is soft or marshy, piles should be driven, and a platform of concrete formed on it, and on this the masonry or brickwork is built.

Movable Cranes (Drawing No. 6).

For dock and wharf work cranes are made portable, and are run on rails to any spot required. Hydrants are placed at various points in the pressure mains, with convenient means of attachment at the base of the crane. A sliding or telescope pipe is used to admit of some adjustment.

The crane is usually made with the working cylinder fixed inside the post. It is more convenient for light weights to dispense with the swinging gear.

The valve motion is much the same as in the other cranes.

This class of crane possesses many advantages for dock or wharf work, especially in the latter case, the wharf usually being by the side of a tidal river. At the fall of the tide the vessel grounds, and when discharged, or all the goods taken out of one " hold," the crane can be moved on to next hold, or another ship or craft.

Some difficulty was experienced at first use of these cranes, on account of the joints leaking; subsequent improvements have now got over this difficulty.

A leading dock manager, and a great authority on "Lifting," has lately stated, " he would always use hydraulic cranes in a dock; but in any new dock he would prefer to have them movable."

It must be borne in mind, to make cranes pay they should work as many hours as possible. The above plan allows of this; it also lessens the number of cranes required at a wharf or dock; it keeps the wharf or quay clear, and so allows of extra space for stowage of goods.

Ellington's Patent Movable Hydraulic Winch,

Shown on Drawing 7, consists of a Brotherhood's three-cylinder engine, on the shaft of which is keyed a double drum with brake-wheel, supported on a substantial iron framing fitted with wheels and axles. The front wheels are made so as to turn under the frame for convenience in moving about. The weight of the apparatus is more than sufficient to balance the load to be lifted, and only requires to be kept steady by "chocks" under the wheels.

The engine is controlled by a balanced valve, which is used for starting, stopping, or reversing the engine. In most cases the machine is used with an up and down rope or chain, passed over snatch-blocks. At each lift the engine is reversed, and the only overhauling weight required is that sufficient to balance the chain. Where working with a single chain, by placing the handle of the controlling valve in a different position, the water already in the engine cylinders is allowed to circulate and acts as a water brake, the overhauling weight being sufficient to turn the movable parts.

A series of jointed pipes allows a convenient amount of movement of the apparatus without disconnection with the pressure main, the exhaust water being led back to the return main through a length of hose. The brake is added as an additional precaution to be worked by a handle, and is powerful enough to hold the engine with the pressure on, while it enables the apparatus being used without the engine as a lowering jigger. The machine takes the place of fixed cranes in discharging vessels, and can, if desired, be placed on the deck. It is also used by builders and contractors in towns where a sufficient pressure of water exists. A very high speed of working is obtained, and the height of lift is practically unlimited.

Post Cranes for Railway Work.

The details of the jibs are much the same as before described, but the working cylinders are fixed in the hollow posts, which are usually made of wrought iron, and square. Drawing No. 8 shows this crane in detail. For light weights no swinging gear is attached. They are very useful cranes, rapid in working, and easily controlled.

Special arrangements are made, as shown in Drawing No. 9, where the ram cylinder forms part of the post. The crane is swung by the usual separate cylinder. These cranes are very handy where the weight and height to be lifted are about the same. In many cases, especially when the weights are light, no swinging gear is attached, this operation being easily done by hand. The valve gear for both these cranes is of the usual type.

Warehouse Cranes.

The jibs consist of two wrought-iron slabs with cast-iron distance pieces between. The jib-head carries a grooved wheel; the chain passes from the cylinders through the foot and up the hollow post of jib, to this pulley. The hook is made with a safety spring, and near this is fixed a cast-iron ball sufficiently heavy to run out the chain.

The jib is carried on a cast-iron plate, well bolted to the walls, with top and bottom bearings for the jib to work in. Pipes should be carried from inside the building to the bearings, for the purpose of oiling.

Working Cylinders.—These are the same as described for the wharf cranes, except that the cylinders are usually fixed vertical on the *inner* wall of the building, and in most cases, only one lifting cylinder is used, the cranes raising a certain maximum load, separate cranes being fixed where required to take the heavy loads. The valve boxes and levers are same as before described. Separate cylinders are used for swinging the jib, applied in same way as the wharf cranes.

Johnson and Ellington's Patent Double-Power Hydraulic Crane.

Plate 10 shows a form of double-power crane which is in extensive use and merits notice. A single sheave is mounted on the head of the ram working in the cylinder, and the ends of the chain passing over the sheave are attached to smaller sheaves, one on the one side and two on the other. Either of these sheaves can be locked so as to form the fixed end of the chain passing over the ram. When one end is fixed the crane will lift a greater load than when the other is

fixed. An ordinary hydraulic crane, constructed to lift 25 hundredweight 40 feet, would for each lift use the same quantity of water, whether the load were 25 or 10 hundredweight; but in this crane, with the same size of ram, it would only make half the stroke, using half the water, when lifting the lighter load.

It is specially adapted for working high warehouses where the loads vary, as, without increasing the size of the apparatus, a 10 or 15 hundredweight crane is made to lift 20 or 30 hundredweight half the height. In cases where heavy goods are landed on to a quay, and light goods only warehoused in the top floors, the saving effected by this system is very great; and the lighter loads can be lifted at an increased speed. Between sixty and seventy lifts per hour is an ordinary speed of lifting.

Thornton's Double-Chain Sack Hoist.

Drawing No. 11 shows an improved sack hoist fixed in the roof timbers of the building, and arranged for one chain to lower while the other is hoisting. There are two hydraulic cylinders and rams with chains led over multiplying sheave on the ram-head and corresponding sheaves on the cylinder end, and on to a chain wheel which, in its turn, actuates the two winding drums. The working valve is arranged to open each cylinder alternately to the pressure and exhaust, thus raising and lowering each chain. With one of these hoists as much as 1400 quarters of grain have been stored in a warehouse sixty feet high in ten hours.

Coal Lifting.

The cranes usually have a radius of 21 feet, and lift, about 40 feet, a coal bucket containing 15 hundredweight at each lift. At the large floating vessel belonging to Messrs. Corrie and Co., the average annual work is equal to 1½ millions of tons, from, say, 1800 ships; the maximum in one week being 53 ships, discharging 47,160 tons of coal.

Three cranes will discharge a ship of 900 tons of gas coal in 7½ hours.

On one occasion 872¾ tons were cleared in 4¾ hours, equal to 61¼ tons per crane per hour, delivered and weighed.

At another time *one* crane discharged 480 tons of coal in 8¼ hours, equal to 58¼ tons per hour. Another 64 tons in 59 minutes, equal to 65 tons per hour.

The author believes the above work is the largest amount ever done by hydraulic cranes for this class of work.

These cranes multiply 8 to 1, and give a high working result.

The coal skips used are 3 feet 6 inches in diameter, by 3 feet 3 inches deep, and hold 14½ to 15 hundredweight, according to the kind of coal.

The cranes are tested once per month, and kept in proper working order.

Cost of working the machinery, including maintenance, repairs, but exclusive of interest and the men in the "hold," is about 1*d.* per ton lifted; taking all expenses, the cost may be put at 2*d.* to 2½*d.* per ton.

The cranes *weigh at the same time as lifting.* The machines for this purpose are tested by the meters once per month.

The above data as to amount of work done will only apply to places of like magnitude.

CAPSTANS.

These useful apparatus are shown in the Drawing No. 12. They consist of two or three hydraulic cylinders with ram pistons working direct on one crank shaft. They are fixed immediately under the capstan-head, to which they give motion. The valve gear and levers are of much the same construction as the cranes, and are fixed in a convenient place. Guide pulleys are fixed at various spots, so as to be able to draw the trucks in any direction. Some discussion has taken place as to the shape of the "head;" the author considers it is advisable to use them with a slight taper only.

BROTHERHOOD'S PATENT THREE-CYLINDER HYDRAULIC CAPSTAN.—The three-cylinder capstan shown on Drawing No. 13 is one of the best applications of Brotherhood's engine, and the capstan itself is worth notice, as it was the first constructed in which the engine and capstan were made self-contained on one bed-plate. The engine is coupled direct to the capstan-head.

An important feature of three-cylinder single-acting engines

is that the moving parts are only subjected to strain in one direction, and in the Brotherhood engine advantage is taken of this in a particularly neat arrangement of the connecting rods, which all work on one crank pin, and are always in compression.

The simplicity of the construction of this capstan is shown by the fact that it can be taken to pieces and put together again in less than half an hour.

Capstans are largely used by the railway companies and others for hauling wagons in the goods yards, and a train of 12 to 20 loaded wagons can be drawn by a single capstan. The controlling valve is actuated by a treadle.

The engine working direct on to the capstan, as in Brotherhood's, reduces friction to a minimum, and the absence of gearing and alternate strains renders a breakdown a very rare occurrence.

The use of capstans ought to become general in private works, the cost is not half that of horse work, and when hydraulic power is otherwise used the first cost is not high.

In cases where it is undesirable or difficult to construct a pit (generally about four feet deep) under the capstan, Mr. Ellington has introduced an improvement by which the capstan is lifted bodily about two feet above ground without breaking any pipe joints, thus giving access to the working parts, while the working of the engine can be tested in its raised position (see Drawing No. 14).

Swinging Dock Gates.

Hydraulic apparatus as before described is used for this purpose, with chain gear from same to open the gates, as shown in Drawing No. 15. The work is done by a small hydraulic engine, with barrel to coil the chain on, somewhat similar to the engines used for capstans described above. The details of the apparatus vary to suit special cases. The three-cylinder engine is very suitable for such purposes.

CHAPTER IV.

SWINGING APPARATUS FOR BRIDGES.

For heavy iron bridges a very useful application of hydraulic power is made. The pin upon which the bridge turns is raised by hydraulic power to take the pressure off the rollers and leave all perfectly free. Hydraulic cylinders with chains and wheel, same as for the cranes, are used for working, or small hydraulic engines with wheel and rack gear fixed to the under side of the bridge. When the weight of the bridge is considerable, the whole weight is not taken off the centre, on account of dangerous oscillation; usually about two-thirds is taken, leaving one-third on the rollers.

The largest bridge of this kind is the one across the Tyne at Newcastle; it is about 280 feet long and weighs upwards of 1200 tons. The author has seen this bridge swung open, allowing one vessel to pass, and close again in three minutes with the greatest ease.

Turn-Tables for Railways.

Hydraulic power is applied to these in much the same way as above. The turn-tables can either be worked by cylinders as before described, or by the small hydraulic engines working in a rack or wheel fixed to the centre pin. They are much to be recommended, as at nearly all large railways hydraulic power is available.

Hydraulic Hoists.

Wagon Hoists are used at the various railway depôts and other places (see Drawing No. 16). They consist of a platform about 22 feet by 9 feet, capable of taking a loaded truck. The table is constructed of wrought iron, powerfully framed with

4-inch timber platform, on which are fixed the rails for the trucks to run on. At the top of table are fixed vertical trough irons to form guides, and at the top a cross girder; the chain is attached to this, and passes to the counter-balance. The vertical irons are stayed diagonally.

A ram 9 inches diameter by 20 to 25 feet stroke, equal to the height to be raised, is securely fixed to the lower part of the iron framing of the platform. This ram works in a cylinder with a bored head, and provided with leather collar packing; this is sunk in the ground. The table is guided at the sides by cast-iron planed bars fixed to strong timbers.

The valve gear is much the same as for the cranes. Self-acting stopping gear top and bottom is provided in all cases. Generally these lifts are fitted with an extra small ram and cylinder, by which means part of the water is saved when the table descends, the small ram being used also to take up the empty table.

The load raised is about 15 to 16 tons; the pressure usually employed is 700 to 750 lbs. per square inch.

LIGHT TRUCK HOISTS.—A modification of the above is also used in warehouses and factories to carry up light trucks containing goods, and where the weights are light; the rams are small in diameter; to give them sufficient strength, they are made of solid wrought iron or steel. Counter-balances in these cases are not generally used when heavy pressure is at hand.

The valve motion is of a very simple kind. The table or platform is made of wrought iron, with hard wood top. Self-acting stopping gear is attached to stop the lift at top and bottom, to prevent accidents.

CHAPTER V.

HYDRAULIC CANAL BOAT LIFT.

THE author here gives (see Drawing No. 17) a description of the lift at Anderton, on the river Weaver, designed by Mr. Edwin Clark, M.I.C.E.

The difference of height between the river and the canal at this point was 50 feet 4 inches. The lift was designed to raise the barges direct through this height, and save expense and time of passing through locks.

There are two lifts; the barges are raised and lowered when floating in a trough of water, it being arranged that the barges descending in one lift should help to raise the barges in the other lift. The size of these troughs is 15 feet 6 inches by 75 feet long; they will hold either one of the largest or two of the small ordinary barges: these latter will carry, say, 40 tons, and the largest 100 tons. The sides of the troughs are wrought iron, 9 feet 6 inches deep at centres and 7 feet 6 inches at the ends. The depth of water in the troughs is 5 feet.

At each end of the troughs there are lifting gates, and syphons at the side to regulate the depth of water required.

Each ram is 36 inches in diameter; of cast iron, in three lengths, bolted together.

Weight of each trough, with the water and barges, equals 240 tons, or a pressure of 4¾ hundredweight per square inch on the ram.

The details of the ram and cylinders are the same as the ordinary hydraulic lifts for heavy pressures.

The well cylinders are 5 feet 6 inches in diameter.

The accumulator to work the lift has a ram 1 foot 9 inches in diameter, by 13 feet 6 inches stroke, and has a

capacity equal to one of the main rams for a stroke of 4 feet 6 inches.

The two rams are in communication by a 5-inch pipe fitted with an equilibrium valve for opening and closing communication between them. The pipe from the accumulator to the ram is 4 inches in diameter.

The weight of each trough, etc., is the same when the same depth of water is in each. Suppose the heavier one descending with, say, 5 feet of water against 4 feet 6 inches in the ascending trough, the valve between the rams being opened, the lighter one will be raised to within, say, 4 or 5 feet of the top. The rest of the lift is done by the accumulator.

It is essential that the depth of water in the *ascending* trough should never be more than 4 feet 6 inches, the extra water being drawn off by the syphons; there are twelve of these to each trough.

About $\frac{11}{12}$ of the entire lift is done by taking a layer of water 6 inches deep out of the *ascending* trough; this is about 15 tons. The $\frac{1}{12}$ to complete the lift is performed by the accumulator.

Each ram and cylinder, with its trough, is in turn an accumulator to the other, and does its own work in lifting and lowering.

TIME.—The lift will take up and bring down two barges in eight minutes. Had this been done by a series of locks, it would take $1\frac{1}{4}$ hour to $1\frac{1}{2}$ hour for each barge to pass through.

Each trough can be lifted separately by the engine and accumulator. This is a slow operation, and takes half an hour.

The lift is capable of transferring sixteen barges per hour—eight up and eight down.

The barges can be raised the whole height, equal to 50 feet 6 inches, in three minutes.

In the event of one ram and trough only being used, viz. a single in lieu of a double lift, a much larger pumping engine and machinery would be required.

The details of the guides, valves, etc., are much the same as for heavy hydraulic hoists.

The advantage possessed by this apparatus over locks, is the small amount of water used, and the time saved.

Staff of men required, five. Total working expenses, £10 weekly.

The total cost of the lift work was £29,463. The work was done in 1872, when iron was much higher than at present; and with many modifications that would be made in one at the present time (1881), it would cost considerably less.

The above apparatus is a most ingenious application of hydraulic power. The designer has stated that he would another time use a single ram and trough, worked by a large accumulator; $\frac{1}{3}$ of the cost would be saved, and as much work done per day as with the double lift.

CHAPTER VI.

HYDRAULIC HIGH-PRESSURE LIFTS AND HOISTS.

Lifts for Passengers, for Hotels, etc. (Drawing No. 18).

When worked on the high-pressure plan, they consist of a long cylinder sunk in the ground, with a ram working in same, having a stroke equal to the whole height to be lifted. To the top of the ram the cage or ascending room is attached. This room is formed of strong iron framing well braced together, with an iron roof, to prevent accident from weights falling on top of same. The floor is of wood, and the sides are wood lined.

Two cast-iron guide bars, planed, are fixed to stone templates built in the walls; and four rubbing guides, lined with gun-metal, are fixed to the cage at the top and bottom. The bars should be set dead plumb, and the rubbers should have no side play. For heavy pressures of water this class of lifts does not require any counter-balances. In other respects they are the same as the low-pressure lifts, described more in detail at p. 36.

The valve box is fixed in the basement, with an endless rope passing through the cage to work same. Self-acting stopping gear is made to stop the lift top and bottom. Special appliances are also provided to save accident from any cause.

These lifts, being direct-acting, have no gear of any kind overhead. They are absolutely safe, noiseless in action, and can be worked with great ease. They are, however, only applicable where an accumulator is used, and, on account of the heavy first cost, this is not often adopted when one lift only is required.

Goods and Luggage Lifts.

These are usually worked by short-stroke cylinders, fixed either vertically or horizontally, as described at p. 7, and shown in Drawing No. 4.

The cages are made of iron, with wood floors, and are fitted with an endless rope passing through same to the valves.

Self-stopping gear is also fixed to prevent accident. When heavy pressure of water is used, counter-balances are not required. The guide bars in this case are usually T iron, fixed to timbers or direct to the walls of the building. Safety gear is fixed to the top of cage to save accident in case of the chain breaking; it is advisable to have the top of cage made of wrought iron, the same as the last.

This class of lifts are not suitable for passengers, on account of the unavoidable risk that always attends the use of chains, ropes, etc. The author recommends the long ram lifts *in all cases for passengers,* as the only kind in which *perfect security* can be obtained.

Railway Platforms (Movable).

Hydraulic power is used for working the above. One of this class of apparatus has been at work daily at the Paddington Station of the Great Western Railway for some years. The platform, when not required, is run under the main platform. Others have been fixed since the above; the principle is, however, the same. They are very useful where an occasional communication is required transversely with a central platform at a terminus. When not wanted, they are drawn under the main longitudinal platform.

Coal-Loading Apparatus (Drawing No. 19),

For loading coals from trucks into ships at the river-side.

The trucks are run on to a "lift" table, or platform. The truck is raised by a ram, working in a cylinder. When hoisted to the required height, the truck is tipped by a small hydraulic ram, fitted with trunnions, and the contents shot out of the truck down the iron shoot, into the ship's hold. A pair of doors is fixed across the mouth of the shoot to control the flow of the coal, and stop it when required.

An hydraulic crane of same type as before described is used to form a conical heap of coals, to save breaking the coal in discharging into the ship, sufficient being lowered in buckets taken from the mouth of the shoot, to effect this.

CHAPTER VII.

CLARK AND STANDFIELD'S SPECIAL HYDRAULIC APPARATUS.

In addition to the hydraulic canal lift, already described, and shown in Drawing No. 17, designed by Mr. Edwin Clark, there are several other ingenious applications of hydraulic power to special cases that merit notice here. To make the matter more clear, the author has devoted a special chapter to these, and described the various apparatus in detail.

Messrs. Clark and Standfield have had very large experience in this class of apparatus. The author considers most of the special hydraulic machinery he is now about to describe to be unique of its kind; and that the detailed description will be acceptable to his readers. A short description is given in each case, sufficient to explain the general system. More minute detail could not be entered into, being beyond the scope of the work, and forming, as it would, a book in itself.

The designers of the machinery described in this chapter have the merit of working in a new field, and have carried out some stupendous works in a very ingenious and highly satisfactory manner.

Differential Hydraulic Apparatus,

By which any two weights, balanced hydraulically, may be made to ascend and descend at will by opening or closing a valve.

Let any two equal or unequal weights be supported on hydraulic presses, and the size and number of the presses so adjusted that the weights are in equilibrium, or rather, that one of them slightly preponderates. If we suppose the lighter of the two weights supported on three (or more) presses, and one of these presses be shut off, so that the weight rests only

on two presses, the result will be that the weight will now descend. On opening the communication with the third press it will again ascend, and this may be repeated at will, only a press full of water being wasted at each stroke. As the third press may be of very small size, and the waste of water may be supplied from an accumulator, this forms a very convenient movement for the raising and lowering of guns, as shown at Drawing No. 20, or for similar purposes, such as lift-bridges, etc.

The accumulator is constructed with three presses, A′, B′, A′, and three plungers, A, B, A. They are loaded with the weight, W, which is adjusted to balance the gun, G, supported on the press, C′, and its ram, C. The plungers, A A, are of such dimensions that, when loaded with the weight, W, and connected jointly with the ram, C, they just balance the weight of the gun G, which is therefore free to be raised or lowered without any power except that necessary to overcome friction. When this equilibrium is obtained, a small additional weight, W′, is added on the accumulator, which consequently descends, and elevates the gun, G, to its full height. All this time the plunger, B, is out of action, and is merely connected by a pipe with the supply reservoir. If it be desired to cause the gun to descend, the tap, D, in connection with the small plunger, B, is opened, so as to place all three plungers in communication. The pressure being now distributed over all three plungers instead of only two, causes the weight, W, to ascend, and the gun, G, to descend. If it be again required to raise the gun, G, it is only necessary to close the tap, D, and the weight of the accumulator coming only on the two plungers, A A, again causes the gun to ascend as before; the water under the small plunger, B, being, as before, allowed to return into the supply reservoir. In this way the gun, G, may be raised and lowered at pleasure by turning the tap, D, and the only power wasted is that of the small plunger, B, which is made of such size as to be just sufficient to overcome the necessary friction. It is evident that the same effect of obtaining a slight variation of pressure in the accumulator may be produced by either allowing the weight, W′, to rest on the weight, W, or holding it off therefrom; and this may be done in many ways. For example, it may be effected by the central plunger, in the manner indicated by the dotted lines, X. Thus, if water under

pressure is introduced below the central plunger, and the weight, W′, raised, the gun will descend; but if the weight, W′, is allowed to rest upon the weight, W, the accumulator will descend, and the gun again rise.

It is obvious that, by the arrangement described above, there need be no waste of power except such as may be just sufficient to overcome the friction of the leathers, etc., and one accumulator may be made to operate all the guns in a large fort.

In a second arrangement, they support a weighted accumulator, not on a single press, as is ordinarily the case, but on a group of three, four, six, or more presses, with a suitable arrangement of valves for throwing any one or more of them out of action. Let us suppose the object to be lifted to be a bridge or an ascending platform, with a varying load of vehicles or people; the accumulator is so weighted that when all the presses are in action, the platform slightly preponderates, and descends. If it be desired to raise it, one only of the presses is thrown out of action; the accumulator, now resting on fewer presses, exerts a greater pressure, and the platform consequently ascends. If the load be a heavy one, more of the presses are successively thrown out of action, until the weight of the accumulator, resting on a smaller number of presses, or it may be on only one remaining press, exerts sufficient pressure to raise the platform and its load. By this way very little power is wasted, as the quantity of water consumed at each lift is adjusted to the load to be raised. But there is still further gain to be obtained by employing a similar group of presses under the platform itself. In this case, if the load be a heavy one, it will drive back the water from a certain number of presses into the accumulator under full pressure, where it will be available for another ascent, and the greater the descending load, the greater will be the number of presses which will be enabled to return their power to the accumulator, the others discharging their water to waste. This system is particularly applicable to the case of ascending and descending platforms at railway stations, or at a high-level bridge, where the load, be it of men or of vehicles, is very variable. By this means a large proportion of the power used in raising the vehicles at one end of the bridge is afterwards restored to the accumulators by their descent at the

other end. The same system, when applied to hydraulic cranes for the lifting of variable loads, enables the power to be increased two, three, four, or six times at pleasure.

Messrs. Clark and Standfield employ a somewhat similar arrangement to ensure that any load, such as a ship, or bridge, or a canal lift, when lifted by the simultaneous action of two or several presses, shall remain horizontal at all times. This is effected in the following manner:—Whatever be the number of presses supporting the bridge or other object to be raised or lowered, the same number of presses are grouped together under a single accumulator of the same weight as the load to be lifted. Thus, in a bridge, there might be two presses under each end of the bridge. These four presses would be connected separately to four similar corresponding presses under one and the same weighted accumulator. By this arrangement, whatever be the inequality of the weight of the bridge, a perfectly uniform movement is secured in each of the four groups of presses, and the bridge must at all four corners ascend and descend with the same velocity, and preserve its horizontal position at all points of its ascent or descent. This is shown in Drawings Nos. 21 and 22. This arrangement is eminently suitable for transferring railway trains, either with or without their locomotives, from a low to a high level, or *vice versâ*, and for surmounting abrupt prominences where inclined planes would be very costly in construction and expensive in working.

The compensation is effected by a fixed syphon, S, supported by the tank, T. The accumulator, in addition to its weighted load, W, carries a compensating water-tank, M, which rises and descends with it. The syphon, S, dips into this tank, and as it descends, the tank becomes filled with water and its weight increased; and when it ascends, the water flows back again through the syphon, S, and the load is diminished so as to preserve the equilibrium at all points of the stroke. If a be the area of the plungers, t the area of the tank, and m the area of the compensating tank, the proper size for this tank, when adjusted for perfect equilibrium, will be

$$20m = 2a + (2a \times \frac{m}{t}).$$

The accumulator shown in Drawing No. 22 is formed with several plungers combined into a group, so that when it is desir-

able to cause several rams to ascend at the same time through equal distances, as in the case of lifting the two ends of a bridge or a canal lift, a railway train or gun platform, the several rams employed may be supplied with water under pressure from separate plungers, and all the rams be thereby caused to ascend through uniform distances. *a, b, e, d,* and *f* are the six rams and plungers of the accumulator. Four of the plungers, *a, b, e, d,* are connected respectively by pipes with four hydraulic presses at the corners of the bridges, and the accumulators are so loaded as to descend and to raise the bridge when the weight rests on these four plungers only; *c* and *f* are used for lowering the bridge, and whenever they are placed in connection with the other four plungers, the accumulator rises and the bridge descends.

On the other hand, when the communication with the two presses, *c* and *f*, is cut off, the whole weight of the accumulator comes on *a, b, e, d;* the four plungers descend, and the bridge is raised. Since these four plungers are all independent, and are connected independently to the four presses at the corners of the bridge, all four corners must rise at exactly the same speed and to the same level. When a vessel desires to pass, the bridge is either submerged under water to a sufficient depth to allow the vessel to pass over it, or lifted into the air sufficiently high for the vessel to pass beneath it. In a similar way, a train or gun platform may be raised and lowered by two or more rams supplied with water under pressure from separate cylinders of an accumulator such as above described, and thereby ensure the raising and lowering of the platform in a horizontal position.

Hydraulic Wagon Hoist (Drawing No. 23).

This is designed by Messrs. Clark and Standfield, for raising railway wagons from a lower to a higher level, for contractors' purposes. It is worked by an accumulator capable of lifting one, two, or more wagons at each lift, to a height of 30 or 40 feet, and is calculated to effect a great saving in time and horse power. The accumulator may be the same as shown at Drawing No. 22. The press is shown at A B, at an angle of 45 degrees. Whenever C carries a wagon, D, or other load, it may be raised up to a higher

level at E, where the wagon is removed and replaced by an empty wagon, which descends to a lower level; the power used in raising the platform and empty wagon being again given back to the accumulator as they descend. The accumulator is so arranged as to have different powers. Thus, when all six presses are connected with the empty platform, it descends; if two of these presses be cut off, and the weight of the accumulator be allowed to rest on the remaining four, the pressure is sufficient to raise the platform with the ordinary load; if three of the presses, *d. f, b* (Drawing No. 22) are shut off, and the weight allowed to remain on the remaining three, it will raise a wagon with a heavier load; and if four of the presses are shut off, *a, b, d, e*, and the weight of the accumulator allowed to rest on the remaining two presses, it will be in a position to lift the heaviest load; and all these changes may be made on the instant by opening the valves *g, g*.

HYDRAULIC GRID (Drawings Nos. 24, 25, 26).

Messrs. Clark and Standfield have had large experience in hydraulic machinery for raising of vessels, and have introduced an hydraulic apparatus for docking vessels, which is especially suitable for the shores of tidal waters. In this grid, the presses are placed directly beneath the vessel, whereas in the ordinary hydraulic lifts the vessel is supported on girders. The economy effected by this and other arrangements is such that the designers estimate the cost of such docks as not exceeding, under favourable circumstances, about £5 per ton weight of vessel lifted, which is very greatly less than the cost of any other dock whatever.

Drawing No. 24 shows an end elevation of the grid, with a vessel raised upon it. A A are the presses, B B the rams, C C the pontoon or grid. In Drawing No. 26 the grid is shown in plan, with the skin-plate removed to show the construction, and with the outline of a vessel dotted upon it. The back bone is there shown as consisting of two parallel wrought-iron girders the whole length of the dock; there are also on each side an intermediate longitudinal girder and an outside girder. These are crossed at a right angle by a number of transverse girders, or ribs. Five of these transverse girders

This canal lift has all the latest improvements, and is remarkable for the large size of the hydraulic rams, which are 6 feet 7 inches in diameter, and have a stroke of about 45 feet. In this lift the varying weight of the water in the presses is perfectly compensated in every position, and there is loss of neither water nor power beyond that necessary to overcome the friction of the leathers and guides.

Comparing this arrangement with that at Anderton, described at p. 16, the loss of water is in the ratio of 1 inch to 5 feet, that is, $\frac{1}{60}$; and by comparison with an ordinary lock, the loss of water is only as 1 inch to 45 feet, that is, less than $\frac{1}{500}$;—of course, the area is assumed to be the same in each case. An important point to notice is that, when *loaded* barges are descending and *empty* ones going up, a volume of water equal to the difference between the weights of the ascending and descending barges is raised and passed into the upper canal.

Besides a second series of lifts which have been designed for the French Government, two series of lifts of somewhat similar dimensions have been designed for the Belgian Government, the first of which obtained the Government prize awarded after public competition. This series of lifts was designed for passing a canal over a range of hills between Charleroy and Brussels, where water is not obtainable. In fact, this important feature of the hydraulic canal lifts enables the engineer to carry canals over dry table-lands, where there is no water supply, and where canals with locks would be impracticable. It will also render the construction of canals possible in many districts, and much saving will be effected in the construction of locks, and saving of time in transit of the barges as well as the saving in water.

In describing these canal lifts, the author believes he has brought to the notice of many engineers and others a most ingenious application of hydraulic power which is very little known. He, however, believes there is a grand future before it, and too much praise cannot be given to the designers of such powerful apparatus.

CHAPTER VIII.

GENERAL REMARKS AS TO DETAILS.

THERE are many other cases in which high-pressure hydraulic machinery can be usefully employed, such as for corn warehousing, applications to gunnery, opening of sluices, working large wharf shear-legs, etc. In nearly all these cases the machinery is of a very special kind; it is seldom required, and as the description would take up too much space here, further detail has not been entered into.

The following details and data refer to the machinery described in the previous pages.

VALVES.—Slide valves are not usually so good as "mitre" valves; when, however, they are used, the pressure port should be made V-shape, to allow the power to be applied gradually. The valves and faces must be gun-metal, and the work must be of the best kind. To relieve the heavy pressure on back of the valve, a balanced valve is sometimes employed with advantage. No sharp bends should be allowed, either in the passages of the valve boxes or in the pipe connections leading to and from same.

The size of the pipes must be carefully proportioned to save undue friction. No rule can be given for this, as it much depends upon the pressure used and the circumstances of the case.

SKIPS for unloading coals, sand, etc., may be made of steel plates, and usually hold from 7 hundredweight up to 15 hundredweight. Where one or two cranes are used, the author recommends 7-hundredweight skips, and two for each crane; they should be mounted on three swivel wheels, running on steel pins.

CHAINS should be carefully examined once per week, and

changed once per month. Several spare chains should be kept in case of emergency. Only the best short-link tested chain should be used.

PIPES.—All outside are usually carrried underground in close trenches, and must be well protected from any chance of injury. Those passing through warehouses should be carried on brackets, and be provided with small cocks at various points to drain same in case of frost; they should also be protected by clothing from the effects of the weather. Valves should be placed at suitable points to shut off the water when not required in certain directions, and also for closing in case of fractures to save stoppage to the whole length of the main.

WATER used for hydraulic apparatus must be clean, and should in most instances be drawn from a tank. All gritty matter will sink to the bottom. The suction pipe is placed, say, one foot or more from the bottom of the tank, to prevent any dirt being pumped and passed through the machinery. In all cases the tanks should be closely covered, as before stated.

QUANTITY OF WATER used by 30-hundredweight to 35-hundredweight crane to lift goods from the hold of a ship to the wharf level (allowing for the bulwarks of the ship), is about 9½ to 10 gallons; and to lift the empty chain from the wharf and ready to swing over the vessel, say, 6½ gallons; or, say, 16 to 16½ gallons for total lifting exclusive of swinging.

COST OF PUMPING WATER UNDER PRESSURE.—Taking a pressure of 750 pounds per square inch to be the usual maximum used, the cost is about 10*s*. per 1000 gallons when pumped upon a large scale, such as at docks, etc.; when only for three or four cranes, say, 12*s*. to 14*s*. per 1000 gallons.

All expenses are taken into account—fuel, wages, repairs, and superintendence; interest on capital, and every working expense.

COST of lifting by hydraulic power may be taken at 1·26*d*. per 100 foot-tons. This is an average taken from the returns of seven large places; 15 per cent. is allowed in the above amount for interest and depreciation.

The above supposes the cranes in constant work. It would be safe to take, say, 2½*d*. to 3*d*. per 100 foot-tons for ordinary work, and for small places a much higher rate.

SPEED OF LIFTING.—30-hundredweight hoists and cranes, 4 feet to 6 feet per second; wagon hoists (13 to 14 ton trucks), say, 22 feet in 15 seconds. One 30-hundredweight crane can discharge from a ship to wharf level in eight hours, 460 to 470 tons. Bags of seed can be lifted and warehoused 560 tons 75 feet high in eight hours.

COMPARISON OF COST WITH HAND POWER.—The average working of hand-power cranes requires eight men at the handles to lift 10 hundredweight working 20 sets per hour, or 10 tons raised 40 feet, at a cost for labour of 2*s.* 8*d.* per hour. By the hydraulic cranes, one man at 4*d.* per hour—36 lifts of 15 hundredweight each made per hour; or 27 tons 40 feet high, at a cost of 4*d.*

Hand power, say, 3¼*d.* to 4*d.* per ton; hydraulic, ¼*d.* per ton for labour.

The above is an average taken at one of the large London wharves.

GENERAL REMARKS.

High-pressure hydraulic machinery can be most usefully and economically employed at railway depôts, large docks, wharves, and warehouses, and especially where a number of cranes, etc., have to be worked at some distance from the power. In the case of docks and warehouses, this enables the proprietors to have the engines and boilers at one spot, in a fire-proof building, if necessary, and where one set of men can attend to the whole of the boilers and pumping machinery actuating the accumulators.

Where hydraulic machinery is used, the fire companies do not increase the rates of insurance; the danger of explosion from several boilers (which would be necessary for steam power) is avoided; and wherever extra cranes are required, an attachment can be made to the main pipe with small outlay.

Hydraulic cranes are well under control; in fact, all hydraulic apparatus has had such careful attention from several designers and makers, that the author considers such apparatus are more easily and safely controlled than any other class of

lifting apparatus in use, and he also believes can be more safely and expeditiously worked.

One great advantage of hydraulic machinery is that no wear and tear takes place when the cranes and lifting machinery are out of action—the power at this time is stored up ready for the next time of working. This is a great consideration at a dock or wharf, and other large places of like kind, where the work is intermittent; the cranes can be started at any time, and are ready to raise their maximum load.

CHAPTER IX.

HYDRAULIC LOW-PRESSURE LIFTING MACHINERY.

THIS class of hydraulic machinery is worked on several plans, viz.:

1. By head of water from a tank fixed at the highest point of a building.

2. Where the water companies and town corporations will allow it, pressure is taken from the mains, and the expense of the tank is saved. This is not, however, always advisable, as in case of any accident at the water works, or any unusual demand upon the mains, sufficient pressure cannot be obtained to work the lifts.

3. Where several short-stroke lifts or cranes have to be worked, an air vessel may be advantageously used; water is pumped into same under a pressure of 100 to 200 pounds per square inch.

The great advantage of working the lifts from a tank is, the user is quite independent of all machinery, excepting the power required (in large places) to re-pump the water into the tank. No water in this case is wasted, and the lifts can be used at night without any attendant being required for the pumping machinery, as in the case of high-pressure hydraulic lifts.

The cost of the machinery is far less, and there is very little chance of leakage, etc., on account of the lower pressure in the pipes.

The wear and tear of the machinery is small; the leather collars, when properly fitted in, last for years; the repairs are also small; and the machinery not being subject to the same shocks as the high-pressure lifts, there is little liability to get out of order. The author, having designed a large number of this class, may, from the experience of some years, state that no accident of any kind has taken place to any one using the lifts.

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Passenger Lifts (Drawing No. 18).

The construction of these is in some respects much the same as described, p. 20.

A well is sunk in the centre of the lift shaft, rather deeper than the height to be lifted. When constructed in the London district—where gravel and sand are usually met with near the surface—the water is shut out by sinking cast-iron cylinders; these should be 3 feet in diameter, and in, say, 6 feet lengths, flanged together and well bolted. The first cylinder has a cutting edge at the bottom, and when the clay is reached, they are driven from 2 to 3 feet into same, to form a joint, and prevent the water rising under the cylinder. The rest of the well may be in brickwork, 4½ or 9 inches thick, and either laid dry or in cement; this must depend upon the nature of the ground. Great care must be taken to keep the well vertical.

The cylinders are suspended in the well, and in these the rams work; the length or stroke is equal to the height to be raised. The ram works through a bored head fitted with gland and leather collar.

The cage is attached to the top of ram, and is made of wrought iron, well framed together. The top is ¼-inch wrought-iron plate; the floor oak, and the sides pine.

Cast-iron planed guides are fixed on stone templates built in the walls at each side of the lift hole.

To the top of the cage are attached two wings, to which the counter-balance chains are fixed on either side. These chains work in grooves, and pass over two wheels fixed on the side walls, and so to the counter-balances, which work in iron guide bars fixed each side of the grooves in the wall on either side of the lift hole.

The valve gear to work the lifts is fixed below, and self-acting stopping gear is also provided to prevent accident.

Every possible provision is made to ensure perfect safety.

Short-Stroke Ram Lifts (Drawing No. 33)

Are made in much the same way as the above, except that the cage is dispensed with, and a table or platform is attached to the head of ram. Two iron guide bars are fixed at the

sides, and rubbing guides to the table. It is advisable in most cases to fix counter-balances, to take the weight of the table and part of ram. The wells, cylinders, etc., are as before.

The valve arrangement is similar to the other lifts, but smaller as to pipes, etc. Self-acting stopping gear is provided to stop the lift at the highest and lowest points.

This class of lift is very suitable for banks or any place where valuables have to be stored. The entrance in this case to the safe or strong room is by the lift only; the top plate of table is made of wrought iron, and fits into an iron frame at the top floor, similar to a safe door; a patent lock throwing out eight bolts into this iron frame, is fitted to the under side of the plate; the pressure is left on the ram all night, the gear for regulating this being shut up in a recess, and fitted with an iron safe door and patent locks.

Where heavy safes containing documents for daily or hourly reference are required, the safes are fitted with wheels and run on rails on top of the lift table; rails are also laid in the vault or strong room, by which means the safe is run off into an inner strong room if required; the lift then rises, and brings down any others, and the books, specie, etc.

Short-Stroke Ram Lift (Drawing No. 34).

The general details of this lift as to ram, cylinder, etc., is the same as the last named. The guides are fixed at the *back*, to enable the table to rise *above the level of floor or street* at the top, so as to allow casks or other goods to be rolled off at the level of carts, etc.

A lift of this kind is very suitable for a brewery or wine cellar, where the table rises to the level of the public way, and where no fixings for guides can be obtained at the *front side of the lift* at this level.

There are many other modifications of this kind of lift suitable to special requirements, but as they are seldom used, further detail is not necessary.

The great advantages of lifts (as Drawings Nos. 33 and 34) are perfect safety, noiseless action, and total freedom from vibration; the speed is also under absolute control, and they cannot be overloaded. The wear and tear is very small, even when

the work is constant. The cost of water is not a large item, and is hardly worth taking into account, considering the saving of labour, etc.

All the parts are simple and free from complication, and there is nothing likely to get out of order.

The friction of "ram lifts" is small, especially when the leather collars are well fitted,—it does not exceed 5 per cent. Packed glands of any kind are to be avoided, friction is much increased by their use. The lubricant used should be good sperm or mineral oil, and the ram kept very clean; vegetable or lard oil should never be used.

Short-Stroke Cylinder Lifts (Drawing No. 35).

These lifts are very suitable for raising goods, coals, luggage, food, and other light goods.

The most simple plan of construction is an open top vertical cylinder fitted with piston, having a rack attached to the top side; this rack gears into an iron pinion, and by means of a train of wheels, rotary motion is given to a drum, and the requisite amount of rope or chain is coiled. The stroke of the cylinder and the number and proportion of the wheels are regulated by the height to be lifted. However carefully made, there is much friction in this class of lift, and a good margin must be allowed to ensure sufficient power and to spare to do the work.

The bucket or piston should be fitted with two leathers; hemp or metallic packing cause more friction. All the teeth of wheels should be pitched and trimmed; the back and sides of the rack should be planed, and work against a turned wheel fixed at top of cylinder to form a guide; the working pinion should be provided with shrouds turned on the edges, which also rub on the faced front edges of the rack.

Great care should be taken that all the work is perfectly true and of the best kind, otherwise much power will be lost by undue friction.

In well-constructed machinery the friction may be taken at about 25 per cent.

Short-stroke cylinders (see Drawing No. 4), with chains and movable pulleys, are also sometimes used, and especially where

the working cylinders must be fixed horizontally. More friction takes place with this kind of gear than the one above described, but it may be materially reduced by attention to the quality of the work and proportion of the parts.

The cages are made much the same as those for high-pressure lifts, except that all the parts can be much lighter.

Gear rods or ropes pass up the lift hole to enable the lift to be worked from any floor.

Counter-balances are fitted to these lifts. They are made flat in shape, with planed grooves to run in two L-iron guide bars. The weight of the balances is less than the cage, to give sufficient power for the cage to fall, when empty, by its own gravity, and keep the ropes taut on the drums.

Self-acting stopping and safety gear is also provided to prevent accidents.

Wire rope is the best to use for raising the goods. In some cases two ropes are used, working upon separate drums; if one rope breaks, the other is able to take the load safely, and so avoid accident to the cage and its contents.

Lifts of this kind are very suitable for private houses, to carry up food from the kitchens, also coals, etc., to the various floors. The cost of water is not a large item, considering the great saving in labour and time effected. They are not liable to get out of repair, and are easily worked. The speed can be regulated, load controlled, and the attendant cannot either work the lift more rapidly or take more than the *maximum weight.*

Parcels Lift.

Drawing No. 36 shows a very useful application of Brotherhood's three-cylinder hydraulic engine to small lifts, introduced by Mr. E. B. Ellington. The engine is reversible, and carries a grooved pulley, round which is passed a rope, attached at both ends to the lift boxes, and having an adjustment for keeping the ropes taut. One box ascends while the other descends, thus effecting a great saving in time and power. The boxes can be worked by hand, by means of a second rope passed over the head sheave. A high speed can be obtained; the lifts are quite silent, and casily controlled.

Brotherhood's Patent Three-Cylinder Hydraulic Engine.

Brotherhood's three-cylinder hydraulic engine is a great improvement upon the ordinary Armstrong type of oscillating cylinders.

A really reliable hydraulic engine was much wanted, and as Mr. Brotherhood's has stood the test of several years' constant work, he is to be congratulated on his success.

The working parts consist only of the three pistons and connecting rods, one crank, and one rotating balanced valve and spindle which fits into the driver, and is turned direct from the crank pin.

There are no glands, stuffing boxes, or oscillating joints, and the wear of all the parts is taken up automatically, so that nothing has to be tightened up. The engine is made reversible if required, simply by a modification of the engine valve and the addition of a controlling valve to alter the direction of the flow of water into and out of the engine. Mr. E. B. Ellington has effected some useful improvements in these valves, by which certainty of action is secured. The working parts are all protected; the engine occupies very little space, and will work up to 200 revolutions per minute.

These engines have been adopted for working the hauling gear for the sliding *caissons*, and for controlling the sluices in the extension at her Majesty's Dockyard, Chatham.

Low-Pressure Hydraulic Power can also be employed for organ-pumping, working small engines, turning (small) lathes and other machines, and to a variety of purposes too numerous to detail here.

The author is of opinion that the application of this power is still in its infancy, and if water companies would be more liberal in their arrangements with regard to the use of water direct from the mains, engineers would turn their attention to the design of many kinds of apparatus where water power could be usefully employed,—this more especially refers to machines for domestic use, and in large establishments, where saving of time and labour are so essential.

The great advantages of self-acting water power apparatus of this class are—there is no necessity for a steam boiler; the

consequent dirt and trouble, as well as expense of fuel, etc., for working, is saved; and the apparatus not only works silently and without vibration to the surrounding building, but is more easily controlled than any other class of machine. At no very distant day, all houses of any size will not be considered complete unless fitted with machinery of this kind. The particular attention of architects is therefore drawn to this subject, and the author trusts he has made the matter sufficiently clear to be of practical use to them.

PART II.

STEAM LIFTING MACHINERY.

CHAPTER I.

STEAM CRANES.

THE application of steam power to cranes and other lifting apparatus does not date more than about thirty years ago; and for wharf and other cranes, did not come into extended use until within the last eighteen to twenty years; they are now very largely used.

STEAM WHARF AND WAREHOUSE CRANES (Drawing No. 37).

Steam power is very suitable for wharf purposes; and where several cranes are required, one boiler can work the whole; this should be of ample capacity to be able to meet any sudden demand upon it; when no work is being done by the cranes, the boiler is a reservoir of steam until it is again required. The author some years ago was, he believes, one of the first in London to carry steam long distances, and to prove, when the work is properly designed and well executed, that very little loss takes place from condensation in the pipes. This matter will be treated more fully hereafter.

FIXED STEAM CRANES are the most suitable for a wharf doing a large trade; they should be so situated that any two cranes may plumb the two holds of a ship, and be such a height above the wharf as to prevent the sides or bulwarks of the ship fouling the jibs. The most suitable radius for the jibs is from 17 feet to 24 feet.

The posts upon which the crane works should be of wrought or cast iron, fixed in a base plate of cast iron; this plate must

be bedded upon a good stone, with a sound brickwork foundation. This will be more specially mentioned hereafter.

The base plate has an internal rack or tooth wheel bolted on, with conical face for the friction rollers to work on.

The jib is made of two wrought-iron slabs with cast-iron distance pieces or diagonal bracing; or it may be made like a rivetted girder; in any case it should be spread to the full width of the side frames of the crane, to give it *stiffness*, and prevent any chance of twisting, especially when the load is being swung. It is attached to the side frames at the base by a turned pin.

The top wheel for carrying the chain should not be less than 18 inches for a 30 or 40 hundredweight crane, and have a deep plain groove for the chain to work in; it should run upon a fixed steel pin, not less than 2 inches diameter; should have a wide boss, and be bushed with gun-metal. The bottom pin which connects the jib to the side frames should also be steel; and the cheeks of jib should have an extra plate rivetted on at this point, say, 2 feet long, to prevent the pin cutting, and to give extra strength and rigidity.

Rollers must be fitted between the jib and tie rods to carry the chain when slack, but the chain must not rub on them when at work.

The side cheeks should either be cast iron or wrought iron, the latter being the preferable material, especially for large cranes; in this case all the bosses and bearings are cast iron, and are bolted to the wrought-iron side frames; these frames are bolted on to an upper base plate having a bored boss, which rests upon a collar on the post, and works upon a turned part of same. To the top of the frames is bolted a "cross-head" or stay piece, with bored boss open at the top, working on top of the post, which is also turned.

Machinery for Working.—The steam cylinders are best fixed horizontally on the outside of each side frame, with the connecting rods working direct on the crank pins, fixed in first working pinion on one side, and on the crank disc on the other. Two sets of wheels give motion to the barrel on which the chain is coiled; the centre of this shaft is kept as low as possible to keep the strain near to the base, and save vibration.

The swinging gear is done by right and left hand cones

worked by lever and screw nut; these cones are on the crank shaft, which has two bevel pinions keyed on, working a crown wheel below, and by means of spur wheels which gear into the internal tooth ring on the base plate, the crane is swung as desired.

The first pair of wheels are patent frictional gear; the second pair, iron tooth wheels, pitched and trimmed. The man working the crane, uses one lever to start, stop, and lower, and with the other hand works the swinging gear. Cranes made upon this plan were designed by the author some thirteen years since, and are working to this time economically, and are perfectly satisfactory.

Steam pipes to supply the cranes on a wharf, etc., are carried in a channel underground, with junctions to each crane; the details of this vary with circumstances.

PORTABLE STEAM CRANES (Drawing No. 38).—Cranes are made upon the same plan as before described, except that the whole apparatus is fixed on a trolley on wheels, which also carries the boiler.

In many cases, especially where the cranes are not working in direct lines, these are found the most suitable for the work; they are not so economical as to fuel, etc., in working, as several fixed cranes worked by one fixed boiler.

In all cases, for safety, the crane, when lifting goods, should be fastened by four screw clamps to the rails, as cases have occurred where the oscillation of the crane has thrown it over and very serious results have taken place.

For light loads, cranes are made with the cylinders working direct on the barrel without any wheel gear; they lift in these cases at the rate of 200 to 250 feet per minute; the cylinders must be large, and the stroke about 2 to 1. The barrel for chains must not be less than 6 inches to 7 inches in diameter; 9 inches is a suitable size.

HEAVY LOADS.—Where heavy weights have to be raised, it is found more economical to have one or more special cranes for this purpose; in ordinary cases at wharves the maximum load seldom exceeds 4 tons. Cranes for this purpose are made with two motions, with clutch gear to use either power required, according to the weight of goods to be lifted. As a rule, taking the ordinary work of a wharf, it does not pay to have a crane to lift more than 4 tons direct from the barrel;

but by means of one block, and making all the parts of sufficient strength, 8 tons can be raised.

Apparatus for slinging Goods when unloading by Cranes.

Wrought-Iron Crosses, with four sets of slings attached to same, are used to raise small casks, such as pork, soda, currants, sugar, etc.

For lighter loads, a wrought-iron ring, with four or six chains attached, is suitable for raising small bags or packages. When bags or sacks of materials have to be raised, each chain has a large ring at the end to form a running noose; in other cases a hook only.

A very safe sling, designed by the author some years since for raising casks of wine, oil, etc., consists of one chain with large ring at one end and hook at the other; this chain is put round the cask at one end, passed through the ring, drawn tight, and then round the cask at the other end, the hook being caught in the chain, and leaving sufficient space and slackness for the crane hook to take hold of. It will be seen such a sling cannot slip, and the strain of the crane only tends to tighten it upon the cask. This kind of sling has been in successful and safe use for many years at some of the largest wharves in London.

Sugar when in loaves, and all small packages, are best lifted upon a scale board attached to the crane hook by four small chains, and suspended from a wrought-iron cross fitted with a ring.

Where the goods have to be warehoused, they are best lifted in a box, on three wheels, the front one being made to swivel; when landed, they can be run to any required point. Spare boxes are used, so as to keep the cranes continuously at work.

Fixed Boilers

The most suitable are horizontal multitubular boilers, which require no setting; they take up little room, and are most economical in working. The power should be ample; no loss takes place, as before observed, from having the boilers of ample capacity; on the contrary, much economy is effected.

Steam pipes may be carried 400 to 500 feet with very little loss of pressure; they must be well clothed, and provided with expansion joints. Condense boxes must also be fixed at various points, to keep the pipe free from water.

On the line of pipes, proper valves should be provided, to shut off any portion not required.

Foundations of Cranes.

The foundations should have the greatest care. For 40-hundredweight cranes, the holding-down bolts of the base plate should not be less than 6 feet long, and 1½ inch in diameter.

The brickwork should be in Portland cement, and rest on Portland cement concrete. The top base stone for the base plate of crane should be "York," not less than 12 inches thick.

Where, for the purpose of the jibs clearing the sides of the ships, the brickwork bases stand some height above the wharf line, they should not be less than 6 feet by 6 feet, to ensure stability and to keep the machinery free from vibration.

No special rules can be given as to the depth of brickwork, as it will vary with the nature of the soil and other considerations. In places where the soil is boggy or bad in other respects, piles must be driven, then sawn off level, and 6-inch planking spiked to same; on this a good base of cement concrete should be formed, and the brickwork foundations built on it.

Houses over Cranes.

It is advisable to cover the machinery and the man working the crane with a house; this is made of sheet iron, much saving is effected by this as far as the machinery is concerned, and the men are able to work in all weathers without injury to their health. Objections have been raised to their use, upon the assumption that the men will not be so attentive; but from many years' practical experience of their working, the author is able to say such fears are groundless.

CHAPTER II.

STEAM WAREHOUSE CRANES AND HOISTS.

The general arrangement of jibs and steam-hoisting engines is shown in Drawing No. 39. The handle for working the hoist must in all cases be carried to the loopholes, to enable the man to see the load he is raising or lowering.

There are various kinds of hoisting engines; the forms advised by the author are described.

Drawing No. 40 consists of two oscillating steam cylinders, say, 6 to 7 inches in diameter, by 12 to 14 inch stroke, inclined at an angle, working direct on to crank discs. The cylinders are fixed outside each side frame. One pair of spur (tooth) wheels, pitched and trimmed, give motion to the barrel shaft, on which the chain is coiled. The valve motions are worked by links, keyed on one weight shaft, to which is also keyed the hand-working lever. The man working the crane can start, stop, and lower by means of this lever; there are no clutches to throw out; shocks and consequent fractures are thus avoided.

To swing the Jibs two small steam cylinders are used, with a chain fixed to a grooved wheel keyed on the post; this is on much the same plan as for the hydraulic cranes.

Hoists are also made like the above, but with the cylinders fixed horizontally (see Drawing No. 41). To run both ways, either two eccentrics to each cylinder are used with link motion, or a special valve box, admitting steam on alternate sides of the piston, is provided; this plan has been working some years, and is most efficient in its action. These kind of hoists take rather more floor room, but work with less vibration, than No. 32 kind.

Swinging gear, when required, is the same as before de-

scribed. This is the most direct and efficient, and saves much friction, as against the clutch and gearing plan; it also does away with the risk of fracture from the shocks they would be liable to when the gearing plan is used.

Hoists are made upon the plans of Nos. 40 and 41, but with the cylinders working direct upon the crank pins. They usually run at high speeds, say, 200 to 250 feet per minute, and are very suitable for raising cork, wool, esparto grass, tea, and other light goods, especially when packed in cases or boxes.

In all the above instances, the hoist should have a good bed plate, and be securely fixed, to save vibration. The bed plate should be lipped all round, to take the condensed water, and so keep the floors dry; in addition to this, it is advisable to cover the floor, under the hoists, with sheet lead, in case the condensed water overflows the bed plate,—the goods on the floors are not then damaged.

Hoists are made with fixed cylinders, both vertical and horizontal, with patent frictional gear, and are either single or double geared. One lever starts, stops, and lowers; the brake is always on, and is taken off when raising or lowering. This is a very safe plan, and prevents accident.

The work must be of the highest class, and the shafts and all parts strong, to avoid springing and vibration.

Hoists have also been made to work warehouse cranes, where the load is light, and the lift does not exceed 10 feet, by direct action from a steam cylinder, the stroke of which is made in this case 2 to 1, with movable pulley. The piston rod should be extra large, to be rigid and able to stand any sudden shock; the cylinder can either be fixed horizontal or vertical; the pressure of steam should not be less than 40 to 50 pounds per square inch, in order to work them with economy; care must be taken to protect the cylinder and pipes to prevent condensation of the steam. Arrangements are made in the valve gear to pass the exhaust to the reverse side of the piston, to keep it warm, the waste steam being driven out at the next stroke. This is somewhat complicated, and cannot be described in detail, as space will not admit.

There are many other forms of hoists; but the above are specially recommended by the author as those with which he has had some years' experience, and to which he can bear testimony as to their simplicity of parts and efficient working.

STEAM HOISTS AND WAREHOUSE CRANES FOR WOOL, ETC.

During the last ten or twelve years the number of warehouses for storing tea, wool, esparto grass, etc., have much increased in London. Several good forms of steam hoists have been specially designed for the purposes of rapidly unloading the vans and storing the goods on the various floors of the warehouses.

The author will now describe some of the best kinds of hoists for this purpose, and the arrangement of jibs, etc., most advisable to use in such cases.

Hoists are made on much the same plan as described for Nos. 40 and 41, the cross-heads of piston rods of cylinder being connected direct to the crank discs keyed on barrel shaft. Cylinders are oscillating, 8 inches in diameter, by 12 inch stroke. Barrel for chain, 12 inches by 2 feet 9 inches to 3 feet long, capable of coiling, say, 50 feet of $\frac{3}{8}$-inch chain, which is about equal to the average height of the top floors of warehouses in London.

The ports of the cylinders are large, and all parts made very strong to stand the rapid work.

No. 1 *Form of Hoisting.*—The cylinders are made oscillating, as described for No. 40, and either worked by link motion or by central reversing box as described in No. 41 (p. 47). The side frames of the hoist are fixed to a bed plate in the same way, and lipped all round to catch the condensed water.

In some cases the side frames and bed plate are fixed direct on the wall of the building, with a leaded trough under same, to catch the water, etc., as before mentioned.

No. 2 *Form.*—The cylinders are vertical. The connecting rods work direct on the crank discs keyed on barrel shaft; the size of the cylinder and barrels are same as above. The valve motion is worked by a reversing box, and in both cases, by means of one lever, the man working the hoist can start, stop, and lower the load, and has perfect control over same.

An arrangement can be made by special gear to the barrels to stop the engines when the desired floor is reached.

The Position of the Hoist is best on the floor *below the highest floor* (see Drawing No. 39). This gives sufficient lead to the chain, and allows it to coil regularly and closely upon the barrel, without the aid of guide rollers, which should always be avoided whenever possible.

JIBS should be made of two flat slabs with cast-iron distance pieces rivetted together. The average radius for jibs suited for such purposes is about 7 feet 6 inches to 8 feet; wherever possible the angle of the jib should be 45 degrees. The top wheel should be about 14 inches in diameter, with a wide boss, and work upon a 1¾-inch diameter steel pin. The wheel should have a deep and wide groove, and turned at this part, for the chain to work easily in, and to save friction.

The Carriages for the jib at top and bottom should be fixed to a back plate and bolted to the wall by four bolts passing through two back plates on the other side of wall. This preserves the bearing in exactly relative positions, and also adds rigidity to the wall at these points, preventing damage to same and vibration to the machine.

When the warehouse is a new building, the piers where the cranes are fixed should be built in cement; and where the jibs are fixed near the top of the building, a good heavy parapet or cornice is of advantage to keep the wall steady.

The pins of the two leading wheels at the top bearing should be at right angles with the chain when taut. The grooves should be wide, and the flanges of sufficient depth to just clear each other; this prevents the chain getting jambed when it is slack and the load off. One or more guide rollers must be fixed between the head of jib and the above rollers, for the chain, to rest in when slack; they should not touch the chain when the load is on. These rollers should be bushed with gun-metal and turn on steel pins.

Arrangements should be made for oiling the top and bottom bearings, by means of small pipes. At the lower bearing the crane post should rest on three steel discs fitted to the step plate; these discs should be coned on both sides to save friction.

The Chain should be $\frac{7}{16}$ inch in diameter and have a spring

hook and a ball fixed a short distance above same, leaded on to the chain to prevent it shifting. The weight of the ball should be sufficient to overhaul the chain when running down without a load.

The chain of a steam crane or hoist working at a rapid rate should be changed once per month, and most carefully examined to detect any flaws in the links. It should be passed through the fire and annealed. When there is any sign of wear, the chains should be reversed. In all cases spare chains should be kept ready.

SWINGING GEAR is not usually attached to hoists of this class, on account of the rapidity of working.

The author designed, some years ago, an arrangement of levers and counter-weights to keep the jibs at any required angle. A guard chain is fastened at one end to the front of warehouse, and at the other to the head of jib; the length of this chain is, of course, adjustable to suit the position of the jibs.

Spring Buffers are fixed on the warehouse wall to take the shock of jib when pulled in by a slack rope directly the load is landed; the self-acting gear pulls the jib out again, as the chain descends for the next load. The jib may be kept at any angle desired by a special arrangement of the springs; these buffers stand heavy wear, and are perfectly successful.

The weight of each bale of wool is about 3 hundredweight.

THE SPEED of these hoists is about 250 feet per minute.

The quantity unloaded at a large warehouse in London by five cranes is about 1000 bales of wool in eleven hours. Each crane requires the attendance of two men—one at the hoist, and one to take off and wheel the bales away.

THE BOILERS to work this number of cranes may be either multitubular or Cornish; if the former a less diameter and length will do than in the latter case, and where space is an object this wants careful consideration.

At another large warehouse they had five cranes capable of lifting 20 hundredweight each, and one to lift about 5 hundredweight; they were worked by one 20 horse-power

boiler, at a pressure of 55 to 60 pounds per square inch. Coal consumed, about 2 hundredweight per hour, at about 16*s.* per ton.

One crane working ten hours will land 120 tons of goods, with a lift of 20 feet average; this allows for time in clearing away.

Comparing this with hand power: to lift 12 hundredweight 20 feet, five men will be required, and about 168 hundredweight lifted per hour.

The cost of coal for five or six such cranes, in full work, will be about 4*s.* 6*d.* per day of ten or eleven hours (when coals are at an average price). This assumes the pipes are well protected, and every care taken to avoid loss of steam.

The work done varies at different places, and much depends upon the class of work. Steam of the required pressure is always ready, so as to clear any goods that arrive without notice.

The author thought it would be advisable to give data from actual work, rather than any theoretical deduction from any experiments spread over a short time.

The author had an opportunity some years since to test the difference in cost between hydraulic and steam power, the the result being much in the favour of steam power.

It is needless to say the saving effected between steam and hand power is very large. In all such cases the whole of the expenses should be taken into account same as before named for hydraulic machinery.

The boilers should always be placed in a separate fire-proof building, so that the rates of insurance are not affected. In some cases, where only two cranes are worked, a gas engine or boiler can be used with advantage, although the cost of working, as elsewhere stated, is much more. The gas engine is, however, far more economical than the gas boiler, and possesses this advantage—there is no risk of explosion.

Where three or four cranes are in one line, or say, on one side of the warehouse, the following plan is sometimes used.

This consists of one fixed engine, with shafting and barrel gear either worked by cone clutches or patent frictional gear (see Drawings Nos. 45 and 46). The cost of working on this plan is much increased on account of the extra friction of the

shafting and gear, and the heavy work thrown on to the engine by the cranes situated at the end of the shafting.

The author does not recommend this plan, unless under special circumstances, where those before described cannot be used, or where there happens to be an engine near, used for other purposes.

It must always be borne in mind that the power should be as near as possible close to the work to be done; hence great advantage is obtained by the use of self-contained hoists.

In places where no boiler can be fixed, steam is sometimes hired from an adjoining place, and where power is only occasionally required, it is a most economical arrangement. The rent is charged at per hour, according to the time the machinery runs.

CHAPTER III.

STEAM LIFTS FOR GOODS.

STEAM LIFTS may be worked by any of the before-named "steam hoists," and the steam can be conveyed some distance from the boiler to work same, as in the case of the cranes.

Cages are made with an iron frame at bottom and top, strongly braced together, the floor of oak, and the top and sides of pine; rubbing guides, lined with gun-metal (in case of passenger lifts), are fixed at top and bottom of the cage.

Guide bars should either be cast iron planed on the faces, or wrought T iron, not less than 3 inches by 3 inches by $\frac{5}{8}$ inch, well fixed to timbers or stone templates built in the side walls. These bars should be erected perfectly vertical, and dead plumb all ways, firmly bolted, and should be most carefully fixed at the joints, to prevent any movement or friction at these points.

Counter-balances should be provided, taking part of the weight of cage. They should be flat in shape, and have planed grooves, and should work in L iron guides; these guides must be fixed vertically, and the edges carefully filed to prevent friction and noise in working.

The cage is worked by ropes, either hemp or leather, and in some cases a chain.

The rope for the balance may either be hemp, wire, or leather, or chain in some cases.

The ropes work over a top wheel, which should be of large size, say, 2 feet in diameter, turned in the groove to save friction and injury to the rope; the wheel should be keyed to a shaft, working in gun-metal bearings.

Working Gear.

The Lifts are worked from the inside either by rope or rods, giving motion to the valves of the engines or the driving gear.

The position of the engine, etc., and working gear must depend upon circumstances; it is not material to its successful working. A position about midway on the floors is convenient, or it may be placed at the top or bottom of the building.

Safety Gear (Drawing No. 42)

Should be fixed in the top of the cage of every lift. The following is a description of the plan designed and worked for many years under the superintendence of the author.

The guide bars for the cage are fixed on two timbers, wrought on the two sides and faces; these timbers must be fixed perfectly vertical, and true on all sides.

At the top of the cage is fixed a shaft with one eccentric or cam wheel keyed on at each end of same.

On the other sides of the timbers there are two toothed, or serrated, fixed racks; the rope is attached to the top of this apparatus, and by means of an arrangement of levers, etc., directly it breaks, the cams are thrown into gear, and jamb the timbers on each side, and so stop the lift.

When the lift is running at a speed of, say, 150 feet per minute, the fall of the cage at a fracture of the rope, does not exceed 3 inches.

Many plans have been tried and failed, and, after careful study of such failures, the author introduced the above, and he is happy to say it has worked both safely and successfully.

Particular attention is drawn to this most important subject, as many very serious accidents have occurred, especially in the cotton districts, where lifts are so largely used.

Some years since, the author made a most careful inquiry and personal examination into all that had been done in applying safety apparatus to lifts, and in Manchester more especially, by the courtesy of several of the leading warehouse proprietors, he was allowed to examine their various apparatus.

In many cases it was of the most complicated kind, and when he endeavoured to bring it into action, it *failed.* As in very few of these places they had experienced any serious accidents —chiefly owing to the good quality of the lifts, and the great care given to the ropes—while not making them indifferent to any good apparatus that might be offered them, they had relied upon what they had been accustomed to use. Since this time many very good apparatus have been brought out and successfully applied, and the author can state, from personal experience, that many very serious accidents have been avoided by their use. He is of opinion the Legislature should make it compulsory for all users of lifts to have safety gear attached.

Steam lifts are used for a variety of purposes, but with the exception of small details, the general design of them is as above described; there are, however, some special applications that deserve some notice.

Endless Chain Lift for Passengers.

The first application of this kind of lift was about thirty years since at the General Post Office, St. Martin's-le-Grand.

It consists of two endless steel chains passing over top and bottom pulleys. To these chains are attached at certain intervals the tables or platforms for passengers; as each of these comes level with the various floors, the person wishing to ascend or descend has only to step on or off the table, and be carried to any floor he wishes, having then only to step out when the table is about level with the floor where he wants to alight. The speed is rather slow, to prevent accident; they are not, however, to be recommended where it is convenient to apply any other kind of lift.

The chains should be of steel, with drilled holes, and turned steel pins carefully fitted. The guide bars should be cast iron, planed, and erected perfectly vertical.

Machinery for working is usually a small horizontal engine. This may either be worked by steam boiler, or may be a gas engine. This latter is somewhat more costly in daily working, but as there is no dirt or dust, no skilled attendant required, and the rate for insurance not being affected; in many cases its use may be recommended

This class of machinery requires the most careful examina-

tion from time to time. Owing to the number of moving parts, the work should be of the highest class, and the material of the best description.

All lifts should be examined at fixed periods by competent people; it is not only unsafe to neglect this precaution, but in the end proves false economy, without taking into account the serious risks to human life. Much loss may be saved by repairs in time. Cheap machinery, especially of this class, is to be avoided; well designed and properly executed work will always prove not only the most effective, but the most economical.

Lifts for raising Ore at Blast Furnaces.

One very notable one was erected some years since by Messrs. Samuelson and Co., at their furnaces at Middlesborough. It is of the direct-acting class, very safe in working, but of necessity rather costly in construction, and not quite so economically worked as the ordinary hoists, owing to the unavoidable condensation of the steam in the cylinders.

The average weight of a loaded truck is 14 tons, the height lifted is 40 feet.

The hoist consists of an inverted steam cylinder, 38 inches in diameter, by 40 feet stroke, made in several lengths, flanged and bolted together; the piston rod is connected to the cross-head of cage.

The load is raised by the direct action of steam on the piston and rod, and lowered by exhausting the steam, which is passed to the other side of the piston to keep it warm. The actual exhaust takes place on the next upward stroke.

The simplicity of action and safety well compensate for any want of economy and steam in daily working. The author believes this hoist is unique of its kind, and is not aware of any other having been erected in this country.

There are various other kinds of lifts, both for passengers and goods, in occasional use; but as many of them cannot with due regard to safety be recommended where passengers have to be carried, it is not necessary here to enter into detail as to same.

CHAPTER IV.

STEAM TRAVELLERS AND CARRIERS.

STEAM TRAVELLERS.—The girders should be wrought iron, and either be plate lattice or girders; the end carriages should also be wrought iron, with two large wheels on each side to run on the gantry. These wheels should have double flanges, and be well spread as to distance between centres, to give a good base, and prevent twisting. On the top of these girders, light rails are fixed for the traveller to work on. The gear for lifting should be fixed to wrought-iron frames on four flanged wheels, as before described; single and double purchase should be provided to suit the various loads;—this apparatus is much the same as a crab.

There are two ways of working: First, by shafting; in this case a long square shaft runs down one side of the gantry, driven by the general engine. Second, by steam boiler and steam crab; this latter plan is most suitable for outdoor work, and where the travellers are some distance from each other and must be worked quite independently. The man to work the apparatus in this case stands upon the girders; in the former case he may stand upon the floor or on the girders of the traveller.

FOUNDRY CRANES AND TRAVELLERS.

A very nice arrangement of steam crane for foundry work is the following.

The jibs are made of wrought iron, and work in fixed bases and heads. The gear to work same is fixed on top of the jibs for the racking out motion, and on the post for lifting motion.

A longitudinal shaft runs down on one or both sides of the foundry, and by means of an arrangement of levers and gear four cranes can be worked by one man situated on a platform midway in the foundry, and near the wall.

They are more economical as to expense of working than hydraulic cranes, and are much to be preferred to travellers for this kind of work.

For small heights and weights, cranes may be worked by direct-acting steam cylinders, much the same as those described for hydraulic power; the cylinders and all the pipes must be clothed, and care taken to prevent condensation.

Foundry cranes are also constructed the same as the above as regards the jib, the means of working being a steam hoist fixed on the post of jib or near to same. In this case a man is required for each crane, and the cost of working is rather more than the above.

Endless Chain Hoists (Drawing No. 43).

These apparatus are very suitable for raising casks, bales of goods, etc., where the action requires to be continuous and self-feeding.

They consist of two chains working on octagon drums at top and bottom. At suitable distances "horns" are fixed to carry the cask, etc.; the chains are kept in position by stays, and work at the sides upon cast-iron friction rollers; the shafts of drums, etc., work in two side frames. At the lower part the goods roll down an inclined plane to the lift; in the case of casks, when the horns come round, they are carried up to the top, and by means of rails inclined *from* the machine are run away. When other goods are to be raised, such as small cases, they are carried forward by an endless band, and by means of suitable gear two arms move the package on to small tables, which are fixed to the horns above described; as the goods arrive at the top they are either taken off by hand or by gear of some kind.

These machines can either be fixed vertically or inclined, and driven from shafting or by a separate engine.

The speed should be rather slow, to allow time for the goods to be taken on and off the machine.

The links of the chains may be of wrought iron fitted with turned steel pins, the holes should be case-hardened, and the lengths of links centre to centre made exact. These links should be made as described at p. 61.

Endless Bands for Grain, etc.

A very economical way of moving grain or goods of like kind is by means of an endless band. It may be made of woollen material, india-rubber, or canvas. It works on two rollers equal to the width of the band; wood bearing-rollers are fixed at intervals to support same, and means of tightening are attached at one or both ends of the apparatus.

When cases or goods of this class have to be moved horizontally, the chain is formed of two iron long-link chains, with narrow boards attached to centre of each link. These boards are best made of beech.

The band or chain is driven by strap, and by means of a friction clutch, can be made to throw itself out of gear in case of any obstruction to the goods when travelling on the band. They may be made 150 to 200 feet in length, and work perfectly, if well constructed.

Woollen bands of the above kind are also used for transferring or pumping liquids from one vessel to another. The speed in this case wants very careful adjustment, and varies with the kind of liquid. It is a very ingenious contrivance, and effective in action.

Screws, or "Creepers," for Grain, Flour, Charcoal, etc.

These apparatus are for the purpose of moving such goods in a horizontal direction. They consist of a central shaft, with a wrought-iron bladed screw. The diameter varies from 6 inches to 24 inches. The screw works in an iron casing, trough shape, with top flange and cover. At one end the gear is applied and the other is provided with a small relief door in case of stoppage. The shaft of screw should be fitted with couplings to allow the same to be disconnected easily.

Elevators, or "Jacobs" (Drawing No. 44),

Are so well known that they do not require much detailed description.

For Corn, Malt, etc., the endless band is of leather, with tin buckets fixed to same at intervals. The top and bottom pulleys on which the band works are enclosed in a case, with

suitable bearings. At the bottom an arrangement is made to tighten the band, and a vent valve at the top to prevent firing.

The pulleys should be proportioned according to the size of the buckets; 14 inches diameter should be the minimum size. The buckets must not be placed too close together, or they will not deliver easily.

For Coals and other Heavy Goods, the elevator is formed by two side chains, with iron buckets attached. The two chains are kept apart by stays, and work over cast-iron octagon drums, top and bottom. They are also used to carry up the contents of excavations, ballast, and water, etc.

They are self feeding and delivering, and want very little personal attention.

The chains must be made in the same way as those described for the endless lifts; they should be made in a mould, and carefully drilled by special apparatus to ensure each set of links of chain being the same length on each side.

In some of the large breweries these elevators are from 50 feet to 60 feet high; any inequality in the lengths of the links in such cases would cause an accident and stoppage to this part of the plant—often a very serious matter, and involving heavy losses. This is a case where the work should be of the highest class, and first cost not so much an object as good sound work.

CHAPTER V.

BARREL GEAR WORKED BY SHAFTING. STEAM CAPSTANS.

For raising hops, malt, sacks of rice, corn, flour, etc., this kind of gear is to be recommended, especially where other steam power is required for carrying on the business.

Patent Gear (Drawing No. 45).

The barrel is generally about 10 inches in diameter, and the length according to height to be lifted, worked by patent frictional gear, the large wheel being keyed on the barrel shaft; a small counter-shaft has a grooved pinion on same. It is driven by strap gear from the main shafting, or the pinion may be keyed on the main shaft. The shaft of the barrel has eccentric bearings, and by means of levers connected to each end, the two wheels are brought into contact, and motion is given to the barrel.

Brake gear consists of a solid block of beech turned to fit the periphery of the wheel. This is fixed in a cast-iron box, and by means of screws is capable of adjustment as it wears; much care must be used to fix the brake box rigidly; it must not spring in any way. A counter-weight keeps the large wheel on the brake.

To work same there is only one rope required; the man *pulls* into gear and lets the rope go when he wishes to put on the brake, and when lowering the load, he holds the rope slack.

Self-Acting Stopping Gear is attached to prevent accident, and stop the lifting at the highest point.

All the work must be of the best class, the spindles large, and bearings long; the plummer blocks must be firmly fixed, and the timbers strong, to prevent any springing or vibration. The *success of the working entirely depends upon*

the careful proportion of the parts and perfectly true workmanship.

Cone Gear (Drawing No. 46).

In this case the barrel is the same as before, but in lieu of the patent wheels cone clutches are used; the angle of the cones must be carefully designed. When the barrel is on the main shaft (provided the speed is suitable), the male clutch slides in and out of gear on a feather, by means of a clutch lever of the usual type. The barrel has one female clutch at one end, or sometimes two, one at each end, as shown, bolted to same; the boss of barrel is bushed with gun-metal, and runs loose on the shaft.

The lifting is done by bringing the clutches into contact; and the lever gear is so arranged that when the cones are thrown out of gear the brake is put on, and *vice versâ.*

Self-Acting Gear is provided to throw out at the highest point, as in the last case.

Both of the above work equally well; the circumstances of the particular case must decide which should be used. The author, having had much experience with both, can say they work *silently and without vibration,* and are very safe.

Slack Belt Gear.

The barrel, as before; a large double-flanged pulley is keyed on the shaft. It is worked by a slack leather band, and driven direct from the shafting. It is brought into gear by a long lever having a small flanged tightening pulley on the end. The barrel shaft also has a brake, with brake lever gear and rope. The working lever has a counter-weight to take out of gear directly the man lets go the working rope, and at the same time the brake can be put on.

This plan is only suitable for one or two sacks of corn, flour, etc., and is usually made to lift at a high speed, and in some cases is arranged with a double chain, one on each end of barrel, to coil off and on; the end of each chain has a large ring to form a running noose for the sacks.

Self-Acting Throwing-Out Gear is also provided for this apparatus.

The pulleys to drive should be large diameter, wide, turned (but not too smooth) on the rim and edges of flanges; and

should be curved to give a grip to the belt, which should be $\frac{1}{2}$ inch to 1 inch less in width than the distance between the flanges of the pulleys.

It is better to avoid lacing this belt; it should be rivetted at the joints, or strap fasteners may be used. It is advisable to examine the belt occasionally, to see the joints are perfect, as otherwise there is a liability to accidents if the belt breaks.

Stout single straps are the best; they are more pliable, and bite better on the pullies.

Apparatus of this kind are usually fixed in pent-houses overhanging the road or water, the floor of the house having two sets of oak flaps, hung on leather hinges (where the lift is double), with a hole for the rope to pass through.

The timbers of this house should be rigid, and fitted to stand hard work, so as not to communicate any vibration to the building. The author advises that these timbers be carried some distance back, framed into strong timbers, and properly stayed and strutted.

The sides of the pent-house should be enclosed, to protect the men from the weather when working. The quickest method of working is to lift one or two sacks at a time. Much loss of time takes place when more are raised, both in putting on and taking off the load.

The speed is usually 200 feet to 250 feet per minute. Chains are used, $\frac{1}{4}$ inch to $\frac{5}{16}$ inch in diameter, short link, with a round ring at the end to form a loop for the sacks.

Steam Capstans.

These are made on much the same plan as the hydraulic capstans described at p. 13, except that there are only two cylinders, and the valve arrangement is somewhat different. All the pipes, cylinders, and steam chambers should be coated, and the pipes kept free from condense water by the use of condense boxes carefully adjusted. By means of leading pulleys, trucks, etc., can be drawn in any direction, as in the case of the hydraulic capstans. With regard to the steam pipes, see remarks at p. 66, on steam cranes.

There are many other kinds of steam lifting and hauling apparatus capable of being applied in many special cases; they are not, however, of sufficient importance to need a description here.

CHAPTER VI.

GENERAL REMARKS ON STEAM LIFTING MACHINERY.

STEAM power can be applied in many cases where hydraulic power is not admissible. The cost of working is in favour of steam, both as to coals, wear and tear, etc.; also in the first cost, which is much less, thus reducing the interest on capital and sinking fund, all of which must be taken into consideration in forming estimates to be of any practical service.

Where the insurance offices will not allow any fire, a gas engine can be used with much advantage; in some cases gas boilers have been used, but the advantage of economy certainly is on the side of the gas engines. In many cases the convenience attending their use is so great that the cost of gas is a matter of no moment.

THE COST OF UNLOADING GOODS by steam cranes may be taken at 5*d.* to 6*d.* per ton; this includes all expenses, wear and tear, interest on capital, and depreciation, etc., of plant. It must be borne in mind, the number of cranes must not exceed the trade of the place, or the cost will be materially increased by the loss of dead capital. The positions also of fixed cranes should have very careful attention to suit them to the special requirements of the particular class of business to be carried on at the place.

Cost of working Steam Cranes compared with Hand Labour.—Five warehouse cranes cost, for hand labour, at one of the large wharves, £5 17*s.* 4*d.* per day. Five warehouse steam cranes, cost of working, including all expenses, labour, coal, wear and tear, interest and depreciation, 30*s.* per day; cost of coal per week was 29*s.*

Steam Pipes.—All pipes must be kept at least 6 inches clear of the timbers of a building, and where they pass through floor boards a plate must be fixed on same to protect them from the heat. The same applies to pipes passing through any roof; it must be remembered the steam would otherwise dessicate the wood, and render it short and easily fired.

All pipes in trenches should be laid to fall to the condense boxes; these should not be further apart than 60 feet to 80 feet. It is almost needless to say pipes must be coated with composition or felted, and well protected from the weather. The trenches should be brickwork, and of sufficient capacity to get at the joint of pipes.

Condense pipes, with petcocks, should be fixed in all steam cylinders, and means also be provided to drain the steam and exhaust pipes, when the machines have been standing any time.

Cast-Iron Pipes should be flanged and faced, with the holes drilled and well provided with expansion joints. The best kind are copper or iron discs, which do not rust up and become useless in the same way as the old kind of sliding joints. All bends should be easy, no square elbows used, and where T pieces join the main pipe, the junction should be curved to allow the steam to flow easily. On various points on the top of the main, air-cocks should be provided, which should always be opened at first starting to discharge the air in the pipes, and also the petcocks at the bottom to let out condense water and allow the steam free passage.

Wrought-Iron Pipes should be flanged in places, and be provided with means to allow of easy disconnection and to make repairs expeditiously in case of accident. For this purpose the pipes should have a valve fitted to shut off the steam at various points. The same remarks as for cast-iron pipes, as to flanges, etc., apply, and also as to the expansion joints.

At the cranes and hoists, solid bottom cocks are better than valves, this allows the steam to be instantly shut off in case of emergency; the spanners should always be fastened by screw or chained to the cock.

All blow-off pipes should be fitted with cup and hood to take the condense water; and to save any water falling on the men or the wharf, a small pipe is carried from the bottom of cup to base of crane to take away the water.

The author (as before mentioned) has carried steam pipes long distances, in some instances 500 feet to 600 feet from the boilers, and, where proper means are taken to protect them from the weather, and the above-named arrangements are made, very small loss of pressure takes place.

Steam Cranes are not affected in the most severe frost, and in this way have an advantage over the hydraulic cranes, the pipes of which are sometimes frozen in severe weather.

At large wharves, etc., where the work is nearly constant, only one man should work each crane; it is advisable, however, to have men in reserve in case of illness or absence. This man should be responsible for oiling and lubricating all parts, and keeping the crane and machinery clean. Good wages should be paid to competent men of this class, and encouragement given them, in the shape of small advances on their wages from time to time, when they do their work well and safely. It is a serious mistake to employ incompetent or careless men for this sort of work, as, in the event of an accident occurring through their negligence or want of knowledge, heavy losses may take place, besides the possible risk to limb and life.

PART III.

HAND POWER LIFTING MACHINERY.

CHAPTER I.

WHARF CRANES.

WHARF CRANES, SAY, 7 TONS.—The best form of cranes for a wharf or quay are as described below.

The posts are cast iron fixed in a bed plate, in a footstep in the masonry of well, where they are firmly keyed.

The top part of the post is turned. The side frames consist of two cast-iron cheeks, with top and bottom distance pieces bored out at centre, to fit the turned parts of the posts.

The bed plate is cast iron, strongly bolted to masonry; it has a circular rack, or wheel, at the top, and a conical race for the guide wheels to work in. The post is turned at the centre, and passes through a boss in the base, and is keyed to same.

The jib is of wrought iron, made in same way as described for steam cranes (see p. 43), or it may be of oak, fitted with top and bottom cast-iron shoes. At the top is a grooved chain pulley, 16 inches to 18 inches in diameter, and at the base a conical friction pulley, which works on the race fixed to the base. The pin should be turned, and the wheel bushed with gun-metal. Two wrought-iron tie rods, with eyes at each end, are fixed to the jib-head and the side frames, with stays and rollers to keep them apart and take the weight of chain when slack.

The gear is double or treble purchase, the barrel being kept

as low as possible, and of sufficient length to coil, say, 25 to 30 feet of chain. The steering gear is at the back of the crane.

The brake wheel is usually cast on the side of large spur wheel. The strap should be wrought iron lined with wood. The brake should *never* be applied on the teeth of the spur wheel; it is very dangerous, and serious accidents have happened through this being done.

For raising heavy weights, a movable pulley is used; but when lighter weights are required, this is dispensed with.

It is advisable to cover over the working gear by a hood, made of sheet iron; this protects the machinery and also acts as a shelter for the men in wet weather.

All wheels should be bored in the boss, and all shafts turned It is advisable also to tip the tops of the teeth of the wheels. The pinions should have side shrouds, and not less than twelve teeth. The radius of the winch handles should not be more than 18 inches—the usual radius is 16 inches; and the height of the centre of the shaft not more than 3 feet 3 inches from the ground line, or where the men stand to work.

The bearings should be wide, equal to, say, 2 to 2½ times the diameter.

The chains should be of ample strength, and not worked to more than ½ proof strain. It is to be further observed, when heavy goods are lowered by brake, care should be taken not to subject the crane to heavy shocks by suddenly putting on the brake. A notice to this effect should be posted on the crane; it may be the means of avoiding accidents and consequent loss.

FOUNDATIONS should be of brickwork, resting on a good concrete base, with York base stone at top, not less than 10 to 12 inches thick. All the work should be done in Portland cement, and where the soil is of a soft nature, piles should be driven, cut off at the top, and then planked over; on this platform the concrete base should rest. It must be borne in mind, the first cost of a good foundation will be more than saved by the decreased wear and tear of the crane in working.

Portable Cranes.

The general form of this class of crane, in the details of the working gear and arrangement of the parts, is the same as above, except that the post should be wrought iron, and the cast-iron base plate fixed to a trolley on four wheels.

The gauge of the wheels is usually made to 4 feet 8½ inches, to run upon a railway if required, or to any gauge to suit the special case; the centre of the wheels should be well spread, to give a good base and ensure steady working. The frame is usually made of wrought iron, and the base plate of crane bolted directly on the top; the side frames are made with long tails, to carry a counter-balance box, which is adjusted to suit the varying loads to be raised. In addition to the counter-balance, the wheels are usually clamped to the rails when lifting a load.

Wrought-Iron Jibs in both the fixed and portable cranes are preferable to wood, more especially in hot or wet countries; the wood is liable to decay, and rots or shrinks in the cast-iron sockets. The radius of the jibs can be made adjustable, suitable to various conditions of work; this is not usually done, unless special instructions are given. In ordering or specifying this should be expressly stated. It is not, however, desirable to have this done unless the work requires it, as the cranes do not work quite so steadily as when the jibs are of a fixed radius.

CHAPTER II.

DERRICKS.

Derrick Crane.

These cranes are mostly constructed of timber, are made to take apart easily, and can be transported from place to place; they are very suitable for temporary work, either for light or heavy weights. They are easily taken apart when required to move them to another spot.

The working gear is the same as the ordinary crane; the radius of the jib is adjustable; they can be fixed at the top of a building, to haul up the material, and are usually in this case fitted to work by hand or steam power.

The base timbers in any case must be well spread, and either loaded or strongly bolted to the ground or platform it rests on.

The best material to use in construction is oak, but in most cases they are made of fir, on account of portability and economy as to cost. All the junctions of the various parts are iron sockets; the timber should be kept well painted, to preserve it from the action of the weather.

The gear is fixed to a bed plate or frame, and bolted complete to the post; much care is necessary to ensure this being quite true, to avoid undue strain upon any of the parts.

Foundry Cranes.

The best kind are made of wrought iron with two powers, one for light and one for heavy weights, and are fitted also with a racking out motion.

The post is made of two trough girders with angle irons on the inside. The jib or top member is formed of two girders of the same class, leaving a space between for the chain to work between.

There are two diagonal struts of same section rivetted to the post and jibs.

The working gear is of the usual kind, with the racking out motion worked by a separate winch handle.

The post works in cast-iron steps, at the bottom firmly fixed on a stone base, and at the top in a bearing fixed to the timbers of the roof.

For foreign work it is advisable to construct these cranes of timber, as in case of fracture they can be easily repaired, and, where suitable material is at hand, the timber parts can be made on the spot, and so save the cost of freight and carriage.

The gear in this case is self-contained in a cast-iron frame, and bolted to the wood post of crane.

Platform Cranes for Loading Carts, etc.

These are usually made of timber, with gear to work as before, except that an endless chain, working on to a spocket wheel, is used to raise the load. In this case all the gear is fixed at the top, and the post is left clear.

Cast-iron steps top and bottom are fixed for the post to turn in. These pivots are made of cast iron, with sockets to receive the timber.

In some cases these cranes are made of wrought iron, as for railway coke platforms; upon the whole, they are the most suitable. The author recommends their use where first cost is not an object, as the difference in expense is not large.

They are usually called "whip cranes," and are much used in goods' sheds and railway depôts to load and unload carts and wagons. All the working gear being fixed at the top, much room is saved at the loading stage, and greater rapidity of working is obtained by this kind of gear.

Shear-Legs.

For raising a weight at one spot, where no swinging is required, the best plan is a tripod, formed by three baulks of timber or good poles. The lower ends are shod with iron, and a spike at the bottom of each, to prevent slipping or spreading out when lifting the weight. The top of each timber has a wrought-iron strap bolted to same. A bolt passes through all

three legs with a strong shackle, to which the lifting chain is attached.

A crab motion is either fixed to one of the legs or a separate crab used. This kind of apparatus is very useful, especially for temporary purposes; it is both strong and portable, and can usually be constructed from the material to be found in most localities. Good sound scaffold poles, as free as possible from knots, are very suitable for the purpose; they should be nearly same diameter at top and bottom.

Shear-Legs, with Racking Out Movement.

These are suitable for loading and unloading heavy boilers. When on a large scale, the legs are made of wrought iron, in the form of a tube; the bottom of each leg being attached to a powerful cast-iron base plate by hinged joints. The back strut or stay is also of wrought iron and attached to a sliding plate working in a strong base plate, and connected by a pin to the top of the two legs.

The crab motion for lifting is of the usual kind, with a separate set of gear to rack in and out the legs as required.

These are, as a rule, only used in a large boiler, ship, or Government yard, but the same kind of apparatus made of wood is also very useful for temporary works, and can be rigged up by any good carpenter and smith.

Derrick, with Two Legs Framed.

For temporary work two legs are framed together, shod with iron at the bottom, and stand upon a baulk of timber. Three guide ropes keep the legs in position, and, by adjusting the cords, the load can be moved to any required spot. Where much work has to be done and the legs wanted for some period, they are fixed at the bottom to a frame fitted with wheels; this is not only more convenient for shifting the legs from point to point, but gives facilities also for taking up the load at one spot and depositing it at another. The legs in this case are moved by spur gear connected to one pair of wheels. The power applied to lift the weights may be hand power by crab motion, or by a steam hoist fixed near the spot, the chain being led to the legs by guide pulleys. Special arrangements

are made to allow of the range of movement required for the particular case.

A single scaffold pole is also sometimes used, and, with skilled men, heavy weights can be raised; the pole should be shod as before, and should have very little taper.

There are various other kinds of derrick to suit special requirements; the author, however, thinks they need not be more fully described here, as, with the aid of the above details, many other forms can be devised by an intelligent man.

CHAPTER III.

WAREHOUSE JIBS.

THE best form are wrought iron, as described for the steam cranes (p. 50), made with flat bars.

The working gear is an ordinary crab (for description, see below); this is either fixed to the floor inside the building, or of special make and fixed to the wall.

In some cases the crabs are fitted with a counter-balance motion to bring up the slack chain.

The old style of jib was made with round or square iron; it is not, however, such a good form as the one above, and the author does not recommend their use.

CRABS (SAY 40 HUNDREDWEIGHT)

Are made with single and double purchase gear. The most usual forms have two cast-iron side frames, with bored bosses for the shafts to work in. To ensure truth, the two frames should be bolted together and the holes bored out at the same time. All the holes should be bushed with hard gun-metal, bored out for the spindles to work in.

The spindles and shafts should be turned, and the wheels bored and keyed on same with sunk keys; *flats* on the shafts do not make good work, and should never be used.

The barrel should be bored at each end, and keyed to the spindle. The brake wheel may be cast on the side of the spur wheel; it should not be less than 1 inch thick, and 2 to 2½ inches wide. The straps should be wrought iron, and the lever should have sufficient power for one man to hold 1½ ton easily.

Where the crabs are for inside use, the brake strap should be lined with wood. The side frames should be H section, and have four wrought-iron collared stays, to keep them the

proper distance apart. These stays should be (for 40-hundred-weight crabs) $1\frac{1}{8}$ inch in diameter. The feet of side frames should be wider than the sides, to ensure a good, firm base, and should have a bolt hole in each foot.

Much greater care should be given to the selection of crabs than is usually done, in consequence of which and owing to the competition which exists, very imperfect apparatus are in the market, and too often get used, and in many instances serious accidents are the result.

In purchasing a crab, or in specifying for one, whatever weight is required to be lifted, it should be stated that "*it must be lifted direct from the barrel,*" otherwise, the purchaser will be told "it is never done except with the aid of blocks," and he will get a smaller and much less *valuable* apparatus. This partly accounts for the large difference in the prices of different makers.

Jacks

Are used in various forms. The one known as "Haley's" is one of the best, and not likely to get out of order.

The common screw or bottle jack is very useful, especially for underpinning walls, etc.; it is simple and not liable to fracture, and is perfectly safe.

The hydraulic jack is also useful; they are, however, rather apt to get out of order, and, for a foreign country, are not on this account to be recommended

Differential Blocks.

These very useful apparatus have been most extensively used, and in various modified forms.

The great advantage gained by their use is—when raising, the load will stand without making the chain fast, and in lowering, it can be done as required, and with no danger of the load running away. The chains want renewal in three or four years when much used, as the links slightly stretch and get out of pitch; this causes the chain to slip upon the wheels.

These machines have stood the test of many years, and from

the author's experience of their use, extending over about twenty years, they can be confidently recommended.

Useful application of the above.—A rail can be fixed to the roof or to the main timbers under the ceiling of a building, and a small carriage on two wheels, with hook at bottom, can be run on the rails; and by means of one of the above blocks a load may be lifted and run to any part of the place. The rail may be curved if not of too sharp a radius.

To deliver sacks of corn, etc., from a doorway to a distant part of the warehouse, one rail is fixed with an incline *from* the door to this spot; it ends in a curve, and another rail is fixed inclined the other way back to same spot. A small carriage mounted on wheels runs on the rails, the carriage being suspended under the rails. These are very useful machines, and can be easily constructed by any handy smith. The patent blocks must, of course, be obtained of the maker.

CHAPTER IV.

HAND POWER LIFTS.

THE most important kind of machinery of this class are lifts for warehouses and public institutions. As this class of work has not in many cases received that attention its importance deserves, full details are hereafter given, which will enable the architect or engineer to specify what he requires.. All the examples described are from works actually executed by the author, and which have stood the test of many years' successful and safe working. Many modifications may be made from the various types given to suit special cases without altering the general principles on which they are constructed.

WAREHOUSE LIFTS FOR 10 HUNDREDWEIGHT (Drawings Nos. 47, 48, and 49).

THE CAGE, OR ASCENDING ROOM, should be constructed as follows. The lower frame should be a ring of L iron, 3 inches by 3 inches; on this are bolted oak or beech boards $1\frac{1}{4}$ inch thick, to form the bottom, and battens running transversely fixed on the under side to strengthen same. The front or loading edge of the bottom should be protected by an iron plate, let in flush with the top of the boards.

Two suspending irons at the sides are rivetted to the lower L iron frame, with cross lifting bars at top, say, 6 feet high from the bottom (the height of this will depend upon the size of goods to be lifted); these bars should be 4 inches by $\frac{1}{2}$ inch each; the ends should project $2\frac{3}{4}$ inches beyond the suspenders, to form rubbing guide plates. On the bottom of the suspenders two 4 inch by $\frac{1}{2}$ inch plates are fixed each side for the lower guides. To keep the suspenders rigid, two diagonals

must be rivetted on each side to take the thrust. At the centre of cross bars a wrought-iron plate is rivetted between the two bars, with a hole to receive the shackle of chain or rope; the hole should be drilled and the edges rounded to prevent any cutting of the shackle.

THE GUIDE BARS.—T iron 3 inches by 3 inches by $\frac{1}{2}$ inch. They should be back plated at the joints, and the ends squared. They must be erected vertically and dead plumb on the faces, and bolted to the joists at each floor; if the height of same exceeds 9 feet, they must be fixed to intermediate timbers to keep them rigid; after they are fixed in their place, the front edges must be filed down and all irregularities removed, care being taken to make the joints fair.

The clearance at any part between the guides of cage and the bars must not exceed $\frac{1}{8}$ inch.

The rope working the lift passes over a spocket wheel at top, of a diameter equal to the $\frac{1}{2}$ width of cage, and the centre of the counter-balance at back. In most cases the wheel will be about 20 inches to 24 inches in diameter at the pitch line; the shape of this groove is very important. The rope is gripped by the groove of the wheel, and passes direct to

THE COUNTER-BALANCE.—This is a flat iron weight, rather less than the weight of the cage, with two grooves planed out at the sides. The top part of the weight has a pocket, to add loose weights if required.

Two L iron guide bars, $1\frac{1}{2}$ inch by $1\frac{1}{2}$ inch by $\frac{5}{16}$ inch, are fixed at the back of the table on timbers. The same remarks as to fixing apply to these irons as well as to the main guide irons. The weight should not have more than $\frac{1}{8}$-inch clearance at the bottom of the grooves. The shape of the counter-balance should be narrow and long, to form a better guide.

GEAR TO WORK LIFT.—The spocket wheel is keyed on to a shaft, on which is also keyed a spur wheel and brake wheel. Motion is given to the lift by an endless rope passing through all the floors; thimbles are fixed at each floor to prevent the rope cutting; this rope works a large spocket wheel, say, 3 feet 6 inches to 4 feet in diameter, keyed on to the first shaft at top, on which is a pinion with a sliding clutch; this pinion gears into the spur wheel on the spocket lifting wheel (second) shaft.

By means of a lever and rods passing through all the floors,

the gear can be thrown in and out, so as to allow the cage, empty or full, to fall by its own gravity.

A brake wheel is also keyed upon the spocket wheel shaft; a cord from the lever passes through all the floors; the lever is fitted with a counter-balance to throw it out of gear.

The rod working the clutch gear is made to swivel at the top, and has a handle at each floor; when the rod is raised or lowered to throw the spur wheels in or out of gear, the handle is turned half-way round, and rests upon stops fixed to the side posts at each floor.

The endless working rope at the bottom works in a grooved wheel of the same diameter as at the top; it works on a bracket, in which is a long slot to take the pin on which the wheel turns; this allows for expansion and contraction of the rope, according to the weather. In a long rope for, say, a lift of 50 feet, this will alter 3 inches to 4 inches in length, especially in damp weather.

In cases where the foundations may not be dry, the wheel must work in a cast-iron box sunk in the ground, to protect the rope from wet and moisture.

SAFETY CHAINS should be fixed on side posts at each floor; and the lift hole lined at the sides, to prevent goods, etc., falling out from any of the floors.

SAFETY GEAR, to prevent accident in case the rope breaks, should be fixed at the top of the cage. This gear is specially described (see p. 55).

BRAKES.—There are two plans of working these: first, by keeping the brake *always on*, by means of a counter-balance weight on the lever; second, *brake off*, and rope to pull the same into gear.

The first-named is the safest plan. In case the man working gets nervous or frightened, he usually lets go the rope; the brake is then in immediate contact with the brake wheel, holds the load, and so saves an accident.

In the latter case, where the brake is held in gear by the rope, small lengths should be spliced in the rope at each floor, with cleats to make fast to, when the cage is required to be held at any point.

The brake straps should be lined with beech, well fitted to the brake wheel. Ample power should be provided in the levers to ensure one man holding the maximum load safely.

Hand Power Passenger Lift (shown in Drawing No 39). The details are much the same as Drawings Nos. 37 and 38, except that the cage is constructed in a different way, and lined at the sides with wood, with a roof at the top also of wood. The working rope, in this case, is at the front of the lift. The guide bars are cast iron, planed, fixed on timber runners, and erected in the same way as described for hydraulic passenger lifts.

Well Holes for Lifts — In new buildings, it is advisable to construct these in brickwork, on account of the risk from fire. In several instances, in the author's experience, when a fire has commenced in the basement or ground floor, warehouses have been destroyed by the flames rushing up the lift hole and firing each floor in its ascent. Experience has shown that where lift holes are of brickwork, and even only wood doors or shutters at the various floors, the flames have simply run up to the roof, and burnt that portion, leaving the rest of the building untouched. The fire insurance rates are also less in this case. The author advises warehouse keepers and others, in case of fire in the lower part of the place in the daytime, to have, if possible, all the lift hole doors closed at once; the damage will then be confined to the interior of same. Of course, every night all the shutters and doors should be closed and locked.

Doors to the Lift Hole at the various floors. For these the author prefers wood, and usually made like an ordinary room door or a sliding shutter. In places where the public have admission, the doors should have patent locks, and be only capable of opening, by the attendant in the cage, from the *inside* of the lift hole.

Ropes are the most preferable for lifting, and should always be of ample power; for 10 hundredweight, not less than $3\frac{1}{2}$ inches in circumference; 15 hundredweight, 4 inches to $4\frac{1}{4}$ inches in circumference. The endless ropes should be $3\frac{1}{2}$ inches in circumference, to give a good grip to the hand.

Brake Ropes, $2\frac{1}{2}$ inches to 3 inches in circumference, for the same reason.

It is advisable to examine the ropes and all the gear once per month; and also to test the "safety apparatus," to make sure it is in perfect working order.

The various parts of the lift should be made of sufficient strength to stand the shocks it may be liable to from having the brake suddenly applied when a heavy load is in the cage, or from the rough usage that such apparatus get from the class of men who have usually to work them.

Warehouse Lift, with Gear below (Drawing No. 50).

There are many cases where goods have to be raised and lowered from the ground floor to the basement, and where the gear cannot be fixed at the top; in this case all the working gear is fixed in the basement.

The Table, or cage, is constructed in much the same way as before described, except that the framing for guides, lifting bar, etc., is inverted. The least depth for the iron cross bars, to which the guides are fixed, should be 3 feet; this is for the purpose of keeping the rubbing plates at a sufficient distance apart, to ensure easy working, and prevent vibration.

The guide irons and counter-balance, etc., will be the same as before, except that the latter, with its guides, may require a different arrangement to suit special cases.

Working Gear is usually a special crab motion fixed to the floor of the basement; this is fitted with a winch handle and fly-wheel, or with a grooved wheel and endless rope. Two chains are attached to the cross bars *under* the table, one on each side, passing over two grooved chain wheels, fixed under the ground floor line; at the other sides, two chains pass over pulleys, and are attached to the counter-balances, which slide in L-iron guide bars, as before described.

The table and framing are sunk into a recess in the floor of basement, formed of a rebated curb of oak.

When the table is run up to the top, it forms part of the floor, and can be secured by bolts for safety, or may have a lock, as described for the bank lift at p. 37, but of a less expensive kind.

Warehouse Lift, with Gear below. A.

This modification of the above plan, to suit special requirements of the work and building, is:—

Table and Guides, etc., are arranged as before.

Working Gear.—Two endless pitch chains, one working on

each side of the table, are attached to the cross bar, and pass over two pitch chain wheels at the top under the floor, and two at the basement sunk under the floor; motion is given from a crab gear, as before described, and by means of another endless pitch chain working on wheels on the shaft on which the two lower pitch chain wheels are keyed. Brake gear, etc., is also attached to this shaft in same way as before described.

No wheels (except the crab) are above the floor line, either at the top or basement floor.

Warehouse Lift, with Gear below. B.

This is constructed on much the same plan as above, except that the shaft, having the tooth wheels gearing on to the pitch chain, is fixed at the *top*, under the table. Two pitch chains, one on each side of the table, are attached to the lifting cross bars, and pass over the tooth wheels to a counter-balance on each side. On the shaft at top is keyed another tooth wheel, which, by means of an endless pitch chain, is geared to a crab motion of the same construction as before.

This class of lift is specially suited to a cellar where there is little head room, and where, owing to the foundations and other causes, no gear can be worked below the basement line.

The chains for this class of lift must be of the best kind. A good form, and one much used by the author, consists of square links made of round iron, with flat S connecting links of hoop iron, secured by one rivet at the lap. They are most reliable chains, not subject to fracture, and easily repaired by putting in new links; great care is required in the manufacture to ensure that all the links are exact to pitch.

There are several other adaptations of the above class of lift; but as they are only used for very special circumstances, they need not here be noticed.

Cellar Lifts, Inclined (Drawing No. 51).

In some cases it is advisable to construct the lift to allow the table to rise and fall upon inclined side girders or guide bars.

The gear for raising and lowering the load is much the same as before described.

The table is made of an angle iron frame, with wood top and

with iron framing below, fitted with four friction wheels with flanges.

Guide Girders may be of wrought iron, "trough-shaped," and on the lower flanges of these the wheels of the table run; at the top of the girders a cross girder takes the chain wheel and its carriage.

The chain to raise the table is attached to a cross bar under the table, and thence passes over the pulley to the crab motion.

The details of counter-balance and guides are much the same as before, and must be arranged to suit the circumstances of the case.

Screw Lifts, 14 Hundredweight (Drawing No. 52).

The Table is made the same as described for No. 50. On the under side is fixed a screw $3\frac{1}{4}$ inches in diameter, with a square thread; it works in a gun-metal nut, fitted in the boss of a bevel wheel. The screw rises and falls in a pipe sunk in the ground, and is worked by wheel gear and fly-wheel. The table has two counter-balances at the back, running in L guide bars, as before.

To prevent undue friction and relieve the pressure on the nut, the weight of the table and screw are overbalanced; the wheel in which the nut is fixed has a groove cut in the boss, and a clip working in this groove attached to the cylinder head prevents the wheel lifting.

This kind of lift is rather slow in working; the speed, with one man and 14 hundredweight to raise 10 feet, being two minutes to two minutes and a half. It is, however, absolutely safe, and well suited for raising and lowering valuable goods, such as casks of wine; it also has these advantages—it must be worked down, and at about the same speed as raising; it cannot run away if left alone, and does not require making fast at any point of its *ascent* or *descent*; the motion is steady, and there is no noise in working. The wear and tear is very small.

Rack Lift.

This is constructed in the same way as the above as to table, guides, etc., but is worked by a toothed rack attached

to the under side of the table in lieu of a screw. The crab gear is much the same as before. The pinion working in the rack should be wrought iron, pitched and trimmed.

The rack should be strong, broad in the teeth, and well guided on both sides, in the same way as described for the hydraulic lift (see p. 38).

This form of lift is not generally to be recommended; it is not so safe as others; where, however, the goods are not of much value, and not liable to fracture in case of falling—the action of the gear being rapid both in raising and lowering—they can be used with some advantage.

These lifts are sometimes driven by steam power; in this case the driving gear should be toothed wheels: belts with wood and iron teeth are not safe to use.

Endless Lifts.

These may have hand motion applied; they are described at p. 56, and can be made in various forms. They are suitable for light packages of one size and weight, and where the goods to be transferred are in large quantities, and for the purpose of passing them from floor to floor, either for storing or to another part of the place where the next process in their manufacture is to be carried out. They work slowly, and have to be designed to suit the special requirements of the case.

Rope and Bucket Lift.

This is a very useful lift for taking up books, papers, etc., either from one floor to another or up a staircase, especially where there are no means of fastening to the floors, etc.

Either single or double wheels are fixed at top and bottom. An endless wire rope passes over these, having buckets or pockets attached at various points of the rope; in these receptacles the books, etc., are placed. They are noiseless in action, very simple, the cost is small, and they can be fixed by an intelligent mechanic.

Lowering Machines (Drawing No. 53).

Machines to *lower* casks and other goods, are made self-acting.

The table, guides, etc., are the same as before. The weight of the table is overbalanced by the counter-weight.

No gear is required except a top wheel, shaft, brake, and lever. As this class of machines are subject to heavy shocks, they must be made very strong, and all parts rigid and free from vibration.

In the case of beer casks, part of the centre of the table is sometimes left open, and by means of a spring in the lower floor the cask is tipped off the platform, and by rails falling *from* the machine, is run away to the place required.

The brakes in these machines should *always be on,* and the counter-balance rather heavy for safely holding the load.

The action of the lifts is very rapid, and for lowering goods the quickest and most economical process that can be adopted.

House Lifts for Food, etc. (Drawing No. 54).

For loads of, say, ¾ hundredweight, the best form of construction is :—

Cage.—The lower frame of light angle iron, say, 1¾ inch or 2 inches; top frame 1½-inch angle iron; corner suspending irons also 1½-inch angle iron. The top and bottom frames are diagonally braced on three sides; the floor, of oak, and the inside lined with pine, with one or more shelves according to the requirements of the case.

The guide bars may be 2-inch T iron, and the counter-balance guide bars 1¼-inch L iron.

The working gear consists of a large spocket wheel, say, 30 inches to 36 inches in diameter, with pinion on same shaft gearing into a spur wheel on the lifting wheel shaft. On this is also keyed a brake wheel, fitted with lever, etc.

The lift hole should be enclosed with sliding shutters at each floor, and have a ledge to land the food, etc., on at, say, 3 feet from the floor line.

House Lifts, Double, and for Light Loads.

Where the weight does not exceed 30 pounds, two boxes are used; the rope is attached to the top of each box, and passes over a central wheel; another rope is attached to the bottom of the boxes, and passes over a lower wheel. The guides in this case are usually wood, and form part of the enclosure of

the lift hole. The author, however, prefers 1¼-inch angle irons for guides, as there is much less friction and no noise in working. The extra cost is very small.

Where the loads are heavier, a spocket wheel is keyed on the top shaft, and worked by an endless rope passing through the floors. In this case brake gear is provided, with a rope passing through the floors.

LIGHT LIFTS of this kind, when used at hotels, the best plan is to have one for each floor, to ensure that the various things ordered get delivered to the proper place, and so save confusion; this applies where special orders are given for various articles, and prevents any one on a lower floor taking them off, and causing confusion and much loss of time.

CHAPTER V.

TRAVELLERS.

THE details of the girders and gantry will be the same as described for the steam travellers, p. 58.

The traverser and gear is also the same. To raise or lower goods, endless chains from the top gear reach to the ground, and, by means of spocket wheels combined with worm wheel and spur gear working a barrel on which the lifting chain is coiled, the load is raised or lowered.

Two motions are provided for light and heavy loads.

The traverser is also worked by gear and an endless chain reaching to the ground.

The traveller is moved on the gantry by means of a cross shaft, to which two of the flanged tram wheels are attached. A spocket wheel, with spur gear and an endless chain, works same.

This kind of traveller is suitable for loads to 6 or 7 tons.

In some cases the men stand on the girder to work it, and so keep the floor clear.

TRAVELLER FOR LIGHT GOODS.

For raising wine, etc., up to 20 or 25 hundredweight, two rolled joists are framed on to wrought-iron end girders or plates, on which four flanged tram wheels are fixed.

The traverser is a small frame on four wheels, as before, with a cross bar in the centre; to this is attached a pair of differential blocks, by which means the goods are raised or lowered.

In some cases a worm and worm wheel works a barrel, coiling the lifting chain. An endless chain, working into a spocket wheel at the top, keyed on the tram wheel shaft, moves the traveller as desired.

There are many modifications of the above, but, as they are mostly for special purposes, need not be described.

A single girder or bar, with carrier mounted on wheels, and a pair of differential blocks to lift the goods, is also a very useful appliance, and very inexpensive.

Screw Lifts. For the purpose of raising and lowering loads at one spot, a fixed girder and carrier, to which is attached a screw, may be used. The screw has a capstan fitted to same, with gun-metal nut. These are very useful lifts, and the cost very small, added to which they are safe.

PART IV.

HYDRAULIC PRESSING MACHINERY.

CHAPTER I.

HYDRAULIC PRESSES.

HYDRAULIC PRESSES being now so much used for pressing various kinds of goods and materials, the author proposes to describe the practical application of same. As most of the presses are on the same general principles, he commences with the description of one suitable for most kinds of work.

10-INCH HYDRAULIC PRESS, FOR 3 TONS PER SQUARE INCH (Drawing No. 55).

This consists of a ram 10 inches in diameter, by stroke varying from 1 foot 6 inches to 7 feet 6 inches, according to the sort of goods to be pressed. The cylinder is $5\frac{1}{2}$ inches thick, and cast with a round bottom; it is bored out for 24 inches in depth from top, and at 6 inches (from the top) has a recess in which is sunk a ∩ leather collar. The pressure of water coming upon the thin edge, forces it against the ram, and so prevents leakage. The cylinder rests on a cast-iron base, having a hole in the centre; this casting has four holes for the columns at the outer edges. The head is cast off the same pattern, the hole in the centre being filled up. The columns supporting the head should be best scrap wrought iron, $3\frac{1}{2}$ inches in diameter, with double collars at each end; these slip into recesses in the head and base, and have plates fitted over them and secured by bolts to keep them in position. The whole

strain is taken on the collars, which should be forged solid, and turned; the head and base are also faced at these points, to ensure a perfectly even bearing, the collars also being turned where they seat.

The table is about 4 feet 6 inches to 5 feet by 3 feet 6 inches to 4 feet wide; the top is planed, and the bottom has a bored boss, in which the top of the ram fits; the table is not bolted to the ram, and in case of fracture can be renewed at much less expense.

The base should rest upon a timber frame, bedded on a brickwork or concrete foundation, the cylinder hanging *free* in the middle; it must not touch any part of the foundation at the bottom.

HYDRAULIC PUMPS.—For a press of the above description, two gun-metal force pumps are fixed on a tank containing water or oil, one pump $\frac{7}{8}$ inch to 1 inch in diameter, and one $1\frac{1}{2}$ inch or 2 inches in diameter, and one valve box between the two pumps, with loaded safety valve. Each pump has a strong wrought-iron lever working through guides, the usual plan being to have a casting in the shape of an arch; the centre has a bored boss, through which the top of the plungers work, and one side slotted to form a guide for the lever to work in, and the other for a fulcrum.

When worked by hand power, an extra lever, with a socket at the end, is fixed on to the lever of small pumps, to give the heavy pressure.

The above pumps may be worked by hand or steam power In the latter case, the best plan is by eccentrics and rods, with pins to disconnect when required, and to throw out of gear.

Such pumps are usually made to give a pressure of 2 tons to 3 tons per square inch. If of gun-metal, they should not be less than $\frac{5}{8}$ inch thick. Phosphor bronze is a very good metal to use, being close, and as a rule very sound and free from blow-holes and other defects.

HYDRAULIC COTTON PRESSES.

These presses in most of the details are much the same as before described.

They have rams 8 inches to 10 inches in diameter, by 5 feet 6 inches stroke, and in some cases 7 feet stroke.

The cotton is put into a wrought-iron box from an upper floor; this box is mounted on four wheels, and has a door at the side near the top to take out the cotton after pressing. When filled, it is run under the press, the ram and table rise and lift up a movable wrought-iron plate at the bottom, inside the press box, pressing the cotton against the head of the press. When the requisite pressure is given, the top door is opened, the bale is corded or fastened with iron bands, and pushed out. The ram, etc., then descends, and the box is run out on the rails at the floor level, and a duplicate filled box run under the press-head, when the same operation takes place.

The size of the bale when put into the press box is 4 feet by 2 feet 6 inches by 6 feet to 7 feet high, according to the sort of cotton; when finished it is about 18 inches thick, and weighs about 400 pounds.

The bales are pressed as close as possible, to save freight and cost of carriage, as bulk and not dead weight is charged for.

PUMPS TO WORK PRESSES are usually driven by steam power, and are 1 inch and 2 inches in diameter, or when in very large places, a battery of pumps, say four 1 inch in diameter and four 2 inches in diameter, are set in one tank and worked by cams or cranks.

To run up the press-head and take the first squeeze, the 2-inch pumps are used, and by means of gear these are knocked off at a certain pressure, and the 1-inch pumps then finish. Self-acting valve gear shuts off the pressure from the presses when the maximum is obtained.

For India, where the pumps are sometimes worked by hand capstan, they are arranged in a battery in a circle, commencing with 2½ inches to 2 inches, 1½ inch, 1 inch, and ¾ inch in diameter. As the men walk round with the capstan bars, singing, as they usually do, each pump in rotation, by means of self-acting gear, is thrown out when a certain pressure has been obtained. The natives like this method better than working levers—it does not appear to fatigue them so much, and the work progresses more rapidly.

WOOD PRESS BOXES are sometimes used. They are made 3 inches thick at the sides, and are well bound with iron. They are generally mounted on wheels, and have top doors to open. Fixed boxes are not much used, on account of the loss of time in filling them, during which period the press must

stand idle. These kind of press boxes are very suitable in places where the freight and carriage of machinery are heavy, where wood is abundant and intelligent labour can be obtained. There is not much pressure on the sides of the boxes.

Linen and Manchester Goods Press.

There are usually in a large warehouse ten to twelve hydraulic presses; the diameters of the rams vary from 10 inches to 12 inches and 14 inches, and the proportion is about six 12 inches, four 10 inches, and two 14 inches in diameter. All the remarks which follow apply to a plant of about this power, the author considering the details would be better understood by describing the actual working of such a plant.

The dimensions of these presses are—rams, 10 inches, 12 inches, and 14 inches in diameter, and 4 feet 6 inches to 5 feet 6 inches stroke; tables, 6 feet by 3 feet 6 inches; columns, $4\frac{1}{2}$ inches in diameter; heads and bases, 3 feet by 7 feet by 20 inches deep at the columns, and about 24 inches at the centre of ribs; height from table to under side of head, 6 feet. Cylinders, 7 inches and 8 inches diameter, equal 4 inches thick; 10 inches diameter, 5 inches thick; 12 inches and 14 inches diameter, 6 inches thick. The working pressure is $2\frac{1}{2}$ tons to $2\frac{3}{4}$ tons per square inch.

Three to five presses are usually worked up at *one* time. Speed of pump shafts about 65 revolutions per minute; the pressure pipes are wrought iron and $\frac{3}{4}$-inch bore. The pressure of the steam in the boilers is varied from 30 pounds to 45 pounds per square inch, to suit the work.

The quantity packed by each 12-inch diameter press is four to six bales per hour; the presses run up in two minutes, the average rise being about 4 feet. The rest of the time is taken in packing, etc. Time for 14-inch presses to run up, three minutes.

Each press packs about forty bales in ten hours.

The top of the table, and the heads of presses, have strips of oak on them, leaving spaces through which the iron bands are passed to secure the bales; the bands are rivetted before the pressure is taken off.

Hydraulic Press Pumps.—The pumps for working these presses are six in number, and set on a tank or box, the plungers are $1\frac{1}{4}$ inch in diameter by 3 inches stroke. The barrels and plungers, with the valve boxes, are all of gun-metal.

They are worked by a crank or cam shaft of wrought iron or steel, $3\frac{1}{2}$ inches in diameter, with $3\frac{1}{2}$-inch diameter crank pins. The bearings should be at least 4 inches to $4\frac{1}{2}$ inches wide, and of hard gun-metal.

The crank shaft is carried on an entablature, with the bearings on the *under side* of same; this is done to take the thrust on the framing, and *not* on the caps of the bearings.

The connecting rods to the plungers have knuckle joints, and are fitted with a steel plate "liner," which is set up by a key as wear takes place; this is for the purpose of taking the thrust off the pins, and prevent knocking and noise.

The rods should be $1\frac{3}{4}$ inch in diameter at ends, and $2\frac{1}{4}$ inch in diameter at centres, and made of wrought iron or steel. The cross-heads of same, working on the crank pins, are made of gun-metal, and the caps strongly bolted, and fitted with check nuts.

The pressure pipes are wrought iron, and $\frac{3}{4}$-inch bore, and are connected by three 1-inch diameter main pipes to the presses. There are twelve plungers to each pipe.

Each press requires twelve pumps to put on the pressure to 1 ton per square inch; six are then knocked off by self-acting gear, and finish with six to the full pressure, which varies from 50 to 55 hundredweight per square inch. As a rule this pressure is never exceeded.

Safety valves are provided, one to each set, and one to knock off part of each set when the heavy pressure comes on. These valves are fitted with carefully graduated levers, marked for the various pressures.

The speed of pump shafts is 60 to 65 revolutions per minute; some work as high as 70; it is not however advisable, as it increases the wear and tear of the gear, and, owing to the slip of the water, very little is gained which compensates for this.

The work must be of the highest class to stand the heavy shocks to which it is subjected.

stand idle. These kind of press boxes are very suitable in places where the freight and carriage of machinery are heavy, where wood is abundant and intelligent labour can be obtained. There is not much pressure on the sides of the boxes.

LINEN AND MANCHESTER GOODS PRESS.

There are usually in a large warehouse ten to twelve hydraulic presses; the diameters of the rams vary from 10 inches to 12 inches and 14 inches, and the proportion is about six 12 inches, four 10 inches, and two 14 inches in diameter. All the remarks which follow apply to a plant of about this power, the author considering the details would be better understood by describing the actual working of such a plant

The dimensions of these presses are—rams, 10 inches, 12 inches, and 14 inches in diameter, and 4 feet 6 inches to 5 feet 6 inches stroke; tables, 6 feet by 3 feet 6 inches; columns, 4½ inches in diameter; heads and bases, 3 feet by 7 feet by 20 inches deep at the columns, and about 24 inches at the centre of ribs; height from table to under side of head, 6 feet. Cylinders, 7 inches and 8 inches diameter, equal 4 inches thick; 10 inches diameter, 5 inches thick; 12 inches and 14 inches diameter, 6 inches thick. The working pressure is 2¼ tons to 2¾ tons per square inch.

Three to five presses are usually worked up at *one* time. Speed of pump shafts about 65 revolutions per minute, the pressure pipes are wrought iron and ¼-inch bore. The pressure of the steam in the boilers is varied from 30 pounds to 45 pounds per square inch, to suit the work.

The quantity packed by each 12-inch diameter press is four to six bales per hour; the presses run up in two minutes, the average rise being about 4 feet. The rest of the time is taken in packing, etc. Time for 14-inch presses to run up, three minutes.

Each press packs about forty bales in ten hours.

The top of the table, and the heads of presses, have strips of oak on them, leaving spaces through which the iron bands are passed to secure the bales, the bands are rivetted before the pressure is taken off.

Hydraulic Press Pumps.—The pumps for working these presses are six in number, and set on a tank or box, the plungers are 1¼ inch in diameter by 3 inches stroke. The barrels and plungers, with the valve boxes, are all of gun-metal.

They are worked by a crank or cam shaft of wrought iron or steel, 3½ inches in diameter, with 3½-inch diameter crank pins. The bearings should be at least 4 inches to 4½ inches wide, and of hard gun-metal.

The crank shaft is carried on an entablature, with the bearings on the *under side* of same; this is done to take the thrust on the framing, and *not* on the caps of the bearings.

The connecting rods to the plungers have knuckle joints, and are fitted with a steel plate "liner," which is set up by a key as wear takes place; this is for the purpose of taking the thrust off the pins, and prevent knocking and noise.

The rods should be 1¾ inch in diameter at ends, and 1¼ inch in diameter at centres, and made of wrought iron or steel. The cross-heads of same, working on the crank pins, are made of gun-metal, and the caps strongly bolted, and fitted with check nuts.

The pressure pipes are wrought iron, and ¾-inch bore, and are connected by three 1-inch diameter main pipes to the presses. There are twelve plungers to each pipe.

Each press requires twelve pumps to put on the pressure to 1 ton per square inch; six are then knocked off by self-acting gear, and finish with six to the full pressure, which varies from 50 to 55 hundredweight per square inch. As a rule this pressure is never exceeded.

Safety valves are provided, one to each set, and one to knock off part of each set when the heavy pressure comes on. These valves are fitted with carefully graduated levers, marked for the various pressures.

The speed of pump shafts is 60 to 65 revolutions per minute; some work as high as 70; it is not however advisable, as it increases the wear and tear of the gear, and, owing to the slip of the water, very little is gained which compensates for this.

The work must be of the highest class to stand the heavy shocks to which it is subjected.

SPECIAL PUMPING ENGINES FOR HYDRAULIC PRESSES.

ENGINES AND PUMPS COMBINED are sometimes used, constructed upon the following plan. The steam cylinders are horizontal, and the engine coupled and fitted up in much the same way as those described for hydraulic crane work; the pumps are worked direct from the piston rod, and vary in number according to special requirements. In cases where these direct-acting engines are used, they only pump for the presses, and do not drive other work.

Another plan is to attach a pair of steam cylinders to the battery of pumps, made as described at p. 93, the tank having a projection cast at each end to form a base plate for the cylinders, which are fixed outside the tank and entablature at each end. A throttle valve in the steam pipe is worked by special levers from the safety valve, to control the speed of the engines to suit the work to be done. The foundations for pumping apparatus of this kind must be solid and good, and the bed plate well fixed to same, by long holding down bolts and plates.

ENGINES FOR WORKING PUMPS OF PRESSES,

For a plant where twelve presses are worked, say, six 12-inch rams, four 10-inch, and two 14 inches in diameter.

To work this number, it requires six sets of pumps, six in each battery, equal to thirty-six total.

Engines.—One pair coupled cylinders, 20 inches in diameter, by 36-inch stroke. Speed, 50 revolutions per minute. Pressure of steam, 35 to 40 pounds per square inch, and 50 pounds when full work is on.

Expansion gear should be fitted to the engines, and a good governor to regulate the speed, as the work varies very much. Steam is usually cut off at ⅔ the stroke; this depends upon the work.

One fly-wheel, 13 feet in diameter by 9½ inches wide by 12 inches deep. This wheel should be turned, the edge on the rim, and well balanced.

The crank shaft is 9 inches in diameter, and the bearings 12 inches wide, and made of hard gun-metal or phosphor bronze.

Sufficient power in the engine is provided to work, by steam or hydraulic power, the cranes and hoists in the warehouse. For a plant of this size there would be about four or five cranes and three hoists, each capable of raising 10 to 12 hundredweight, and probably one or two hydraulic passenger lifts, to raise 10 hundredweight each.

Boilers.—Two Lancashire, 6 feet 6 inches in diameter, by 24 feet long; two tubes, each 30 inches in diameter. One boiler only is worked, the other is a spare one.

Pressure of steam required varies with the work; for three presses at one time, say, 30 pounds to 35 pounds per square inch; and five presses at full pressure of 2½ tons per square inch, say, steam, 45 to 50 pounds per square inch.

The boilers are usually placed in a separate building, to reduce the risk from fire and keep down the rates of insurance.

General Remarks.—When five presses are at work at one time there are usually ten to twelve presses altogether, it being arranged that the extreme pressure can be taken with three or five presses; while the bales are on, the other ones are being finished, and the rams run down, and tables reloaded.

Very special arrangements require to be made in the pipes to take off shocks. The valves used for letting on the pressure must be gun-metal, and of the best manufacture.

Hydraulic accumulators can also be used; the pressure is more continuous, and can be stored up by the engines when the presses are out of gear.

This is a case where a differential accumulator can be applied and much power saved, by reducing the water used and consequent amount of pumping.

Hay Pressing.

For bundling, the commencing press is 6 inches in diameter, by 7 feet 6 inches stroke. Three or four trusses are usually put into the press; this is about 6 feet high, when pressed one-half, the bundles are taken to a 10-inch press, of about 3 feet 6 inches stroke, to have the final pressure, which is usually 2½ tons to 3 tons per square inch. The thickness of the bale when finished is about 12 inches.

The quantity pressed by two men in twelve hours is about 3 tons.

One ton of hay (ship's measurement) varies from 110 cubic feet to 180 cubic feet, the 10-inch press will bring it to 130 cubic feet; hence a large saving in freight.

One set of pumps, 2 inches and 1 inch, will work two presses, and an engine of 6 to 8 horse-power; the power used depends upon the speed required in pressing It often pays better to employ larger engines and larger pumps to turn the work out quicker.

Davis's Patent Plan

Small presses are used, say, 7-inch to 8-inch rams, by 4-feet stroke. At the press head are fixed two rails, on which two cast-iron boxes run, these press boxes have a movable wrought-iron bottom, and doors at the top at each side The boxes are loaded from hoppers on an upper floor, and are then run under the press-head, the ram and table rises, carrying up the loose bottom plate, and pressing the hay between it and a top plate put into the box after being filled When the full pressure is taken, the top doors are opened, and two wrought-iron clips put on each side of the bale, which is thus clipped or held between the two wrought-iron plates.

The bales of hay are then run away on an iron truck to an oven, where they are heated, and the elasticity taken out; after this, the plates can be removed, and the bales tied with cords.

The size of the bale is regulated for a feed of a horse, etc, for a certain time Much economy is effected by this plan, as great loss takes place when the large bales are used, on the common plan, on account of their size, and also being *elastic;* directly the iron bands are cut, the hay expands to nearly its original size, and if all the bale is not wanted for immediate use, it gets scattered or spoilt.

So rapid is the process, that the author has known each press to be run up 200 times per day The pumps in this case are all 2 inches in diameter, with a very powerful engine, —this is done for speed; the contracts are often taken for the greatest quantity that can be shipped in a certain time. In such cases, no other system can compete with this.

Another advantage of this plan is that oats, beans, bran, etc., can be mixed in the bale; and will keep perfectly sweet for years. The author saw a bale that had been pressed, sent to sea, and returned and opened in his presence seven years after pressing. The interior smelled like new hay; and, although it had been much exposed to the atmosphere, was not in any way deteriorated.

When pressing on this rapid plan, the pipes must be well provided with safety and relief valves, to take the shocks off the pump pipes and presses. The engine should also have a very sensitive governor to shut off the steam when no pressure is being taken from the pipes by any of the presses.

This is a case where the "Accumulator" could be applied with much advantage, on account of the storage of power and the direct control applied to the engine valve to suit the various requirements of the work. It would be advisable to have two accumulators—one for heavy pressures, and one for light; the latter, say 1 ton to the square inch, and the former 3 tons per square inch, and by two lines of pipes and the necessary valves, the two presses could be used at pleasure.

All the work requires to be very strong, as on this system of working the shocks to the machinery are of a very heavy character; and unless all the work is of the highest class, frequent fractures take place, involving not only heavy expenses for repairs, but much loss of time, which in this kind of work is of serious moment.

The perfecting of hay-pressing machinery, especially on this plan, is due to Mr. E. J Davis (the patentee of the process described), and who has carried out this class of business on the most extensive scale.

Oil Presses.

The rams are 12 inches in diameter and 12 inches to 18 inches stroke. Height from base to head, 4 feet; four 3¾-inch diameter wrought-iron columns are fitted to the head and base as before described. The tables for pressing are four, they rest upon steel pins screwed into the columns.

The columns are about 22 inches by 22 inches centres. Head and base, say, 12 inches to 14 inches deep on the outer edge; the ribs in the centre 15 inches to 16 inches deep.

Each table is planed at top and bottom, and has a channel and raised rim all round to receive the oil. These channels have a fall to one corner, at which point a small copper pipe conducts the oil from each table to the receiver below.

In the case of linseed, the meal is put into bags and passed into a stove; the bags when heated are packed on each press table, and the pressure gradually put on. When the required maximum is obtained, self-acting apparatus throws the pumps out of gear.

The quantity turned out is about 40 hundredweight of cake and 10 hundredweight of oil in eleven or twelve hours; more can be done where the rapid style of pressing is used; it is not, however, liked so much as the more gradual work, which is considered to extract the oil more thoroughly, and in the result is, in the author's opinion, the most economical method of working.

The pumps are of the usual character; oil is used in them in lieu of water. The pressure is about 3 tons per square inch, and, say, a total pressure of about 340 tons for a 12-inch ram. For ordinary work this pressure is rarely exceeded.

The column and some parts of the press are bright; this enables the man to keep them clean, and saves waste of oil, etc.

Stearine, and Presses for like Materials

Are constructed much the same as described at p. 89. The material to be pressed is placed in bags and piled up to the press-head. The table has a channel for receiving the liquid extracted, and is fitted with a pipe to run off into the receiver below.

The rams are 10 inches to 12 inches in diameter, and 6 feet stroke. The presses are usually enclosed in a chamber, to which steam heat is applied, and are closed up until the time when the maximum pressure has been given. The dry substance is then taken out of the bags, and the presses loaded again. In large places there are usually four to six, and sometimes more, presses in the chamber.

The pressure varies with the material; it is generally $2\frac{1}{2}$ tons to 3 tons per square inch. The same remarks as to pumps, etc., apply in this case as for the oil presses; the pressure must be put on gradually, and at about the same speed as for oil.

SUGAR-SCUM PRESSES.

The rams are usually 10 inches in diameter, by 2 feet 6 inches stroke.

The details of the ram, cylinder, etc., are the same as an ordinary press.

To the head of the press is attached a square piston. The table carries a cast-iron press box mounted on four wheels; thickness of metal, 2 inches sides and 3 inches bottom. On the inside of this box are cast ribs, and against these ribs four copper plates rest, which are drilled with holes. The sugar or scum to be pressed is placed in bags in the box on the table; the ram and table carry up the box against the square piston at top, which presses the goods, the sugar liquor going into the annular space round the box; a cock and pipe allows the contents to be run away into a receiver at the base of the press. The box when lowered is run out on to rails and the bags taken out. Then distance between the wheels of the press box is sufficient to allow the press table to bear on the *bottom* of the box and not on the *wheels*.

THE PUMPS are usually worked by hand, and are 1 inch and 2 inches in diameter, fixed on a tank of water. Pressure used, 3 tons per square inch. At the time the pressing is being done, plenty of hand labour is available, and as at this period it cannot be otherwise employed, it is more economical than steam power. This is partly on account of the necessary position of the press with regard to the other plant, and the time of the day most suitable for carrying out this process.

HOPS AT BREWERIES.

Spent hops are pressed in the same way as above, except that the press box is made with movable sides, to take out the cake when pressed.

Hops may also be pressed in movable boxes, on the same plan as cotton, two boxes being used to save time. The following is a description of presses and pumps made by Messrs. Thornewill and Warham, and at work at Messrs. Bass and Co.'s and Messrs. Salt and Co.'s, at Burton-on-Trent. The cylinders are 12 inches in diameter, by 4 feet to 5 feet stroke; the pistons are packed with cup leathers.

The pressure pumps are made two sizes—the large ones to

lift the piston quickly after the hops have been pressed, at the same time lifting a series of weights attached to the piston rod. When the piston is at the top of the cylinder, and the box is filled with hops, a valve is opened, which makes a communication between the top and bottom of the piston; the weights then bring the piston down quickly, and the small pumps brought into use to obtain the required pressure. The boxes travel on a rail, and are made slightly tapering, so that the pressed hops can be easily removed.

Drugs and Essence Presses.

For drugs, the ordinary press is used; and for essences, a press with ram 6 inches in diameter by 12 inches to 18 inches stroke, with press box made of gun-metal, tinned inside. In addition to this, the table has a channel all round, to prevent any loss of the liquid expressed. Where the drugs are delicate, the top of table is faced with gun-metal and also tinned.

One pump, 1 inch in diameter, is fixed on a circular tank of water; it is worked by hand lever.

The pressure is about 1 ton to 1½ tons per square inch.

The general details of the press are the same as before described, except that for small presses two columns may be used in lieu of four.

Hat Making.

For making low-crowned felt hats, a very ingenious application of hydraulic power is sometimes used. The hat is placed in an iron mould, which is carefully got up to the exact shape required. A top plunger of same shape is then brought down to the rim of the hat, leaving a space in which is a bag; the hydraulic pressure is let *into* the bag, and an even pressure is thus given to the material. When the hat comes out the shape is perfect.

An accumulator, with 6-inch ram by 4-feet stroke, will work ten presses. The pressure required is 150 to 160 pounds per square inch. The pumps to give the pressure can be worked by the general engine; the distance from the same to the presses is not a matter of much moment. In addition to the accumulator, it is advisable to have a good-sized air vessel, to ensure steady and even pressure. To keep this properly charged

with air, see the former remarks on this subject, under the head of hydraulic lifts.

This same kind of apparatus is applied in various other cases, the details of which vary according to special circumstances.

General Remarks on Hydraulic Presses.

Cylinders.—Where very heavy pressure is used, especially when the strokes of the presses are small, cast-steel cylinders are employed with much advantage. They are, as a rule, absolutely sound, and not porous like cast iron. They are of necessity rather costly; but where the work is heavy, and taking into account the cost of an occasional fractured cylinder, it pays to use the material.

In casting cylinders and rams, the metal should always be run vertically, and great care taken to get off the air and gases, to ensure a solid and good casting. Only a selected description of metal should be used, the moulds carefully dried, and the temperature to run the metal should have particular care. It is necessary to leave the castings in the sand for some time to anneal them, and uncover them gradually.

One great cause of unsound castings is leaving the mixture of metal and the time to run it to ignorant workmen, when it really requires most skilful and careful attention. In the author's opinion, most of the unsound castings may be traced to this cause.

Press Pumps are best made of bell-metal or phosphor bronze, and the various parts of the casting carefully proportioned, to prevent unequal contraction when cooling in the sand. They should be carefully annealed. Much care is required in fitting the cup leathers, and seeing that the recesses for same are the proper dimensions.

Water Tanks, for pumps, must be kept clean and free from grit; they should be covered, and frequently emptied and cleaned out. Oil is the best to use where the goods to be pressed will allow it.

Leathers.—The ∩ shape for the rams, and ⊓ (hat) shape for the pumps, should be made of the best oil-dressed leather, cut out of the *middle* of the back of the hide, and dressed down to an even thickness before commencing the pressing.

The leathers are pressed in cast-iron moulds; the pressure should be gradually put on, and then left several days in the presses to harden. Common leather is useless for the purpose, and will not stand any wear.

When well made, of the best materials, and carefully put in, they last a long time—in hard-worked presses two years and upwards, and those used less often for several years. If, however, they are put in by ignorant people, they do not last long; this is very false economy.

Pressure Pipes.—The best are Perkin's high-pressure wrought-iron pipes. The threads must all be cut in a lathe, and all the various caps, etc., must be of hard, close gun-metal, most carefully fitted. At the junctions with the valve boxes and the hydraulic cylinder, discs of leather must be used to make the joints.

Foundations.—As before stated, at p. 90, the cylinders should hang *free* in the pit; the base of presses should rest on timber, on a brickwork or concrete foundation. On no account should the cylinder touch the sides or the bottom of the foundation, or be grouted in with liquid cement.

Steam Power, Pumps, etc.—The engine power should be ample, and fitted with variable expansion gear, to accommodate the varying work it may have to do. In all cases double cylinder or coupled engines are preferable, as they are more easily controlled, and can be started at any point of the stroke.

Where the presses are worked by an accumulator, the same apparatus is used as described for the cranes, except that more pumps are attached to the engines, to suit the heavy and light pressures.

Valves for Pressure must be of the best materials and workmanship, and should be in solid gun-metal. There are several patented, all which answer the purpose well.

It must be borne in mind that this is a very important matter, as, if leakage takes place, there is much loss of power, especially at the higher pressures, and where there are many presses.

Safety Valves and Relief Valves.—Great care must be taken to ensure instant relief to the pipes in case of any undue sudden pressure, and that the suction valves of the pumps are thrown out of action when the maximum pressure

is obtained. The safety valves should be placed at various points on the pressure pipes, especially where they turn or run in a different direction, to ensure that the extra pressure in the pipes at any point finds relief as near same as possible, added to which, if one valve sticks, one of the others is sure to act. These safety valves should be made with knife-edges, working on flat faces; or, if the valve is made conical, the seat should be very narrow. When the valves and seats are made as above, they are very sensitive, and more likely to give instant relief to the pipes in case of any unusual, violent shock.

CHAPTER II.

HYDRAULIC WORKSHOP MACHINERY.

THE application of water power to punching and other machines dates back some years To Mr R H Tweddell must, however, be awarded the merit of first bringing the same into practical use upon a large scale, for rivetting more especially, by the introduction of his patent machinery; and although his application of hydraulic pressure to portable machines (those which can be taken to the work, instead of having to bring the work to the machines) constitutes the most original and interesting branch of Mr. Tweddell's system, yet the first successful introduction was due, so far as rivetting machines are concerned—

First. To the employment of a very high pressure of water, namely, from 1500 to 2000 pounds per square inch, which reduces the sizes of all motive parts, and, consequently, the weights—some of these machines, although exerting a pressure of many tons, only weighing a few pounds

Second. To the adoption, in certain cases, of a form of accumulator which, so far as the stationary rivetting machines especially are concerned, acts not only as a reservoir, but also as a means of greatly intensifying (for the moment) the above high static pressure; and also allows the full static pressure to be maintained on the rivet-head as long as may be desired. It is to this general combination that the success of *hydraulic* rivetting is due.

Many of the largest boiler, girder, ship-building yards, and wagon companies, have been fitted up upon this system. The author has seen it in action at several large places, and considers it the most perfect machinery of its class, and far superior to a steam power plant.

The working is more economical than any other system, and

the power better under control, while the freedom from vibration, and the saving in costly foundations, especially recommend it for practical use.

In this system on a large scale, no shafting or gearing is required to drive the machines; the power is obtained by pumping water into an accumulator, somewhat similar to those used for hydraulic cranes. The pressure from this is conveyed to the various machines by pipes in the usual way, the power being stored up in the "Accumulator," ready at any moment for application.

Machinery of this class is very inexpensive to keep in repair—the wear and tear, owing to its entire cessation from movement when not doing useful work, being slight, and it costs very little for maintenance.

All of the machines being self-contained and many of them being portable, they can be used in any part of the works, and their distance from the accumulator is not of much consequence. The apparatus is thus very suitable for outdoor work, such as erecting heavy bridges, since all the apparatus can be made portable. A great saving of time and cost is effected in such cases, the work being infinitely better done than by the best hand work, it being well known that, in erecting work outside, hand work is often done under very great disadvantages.

Accumulator

The pressure for rivetting machines is in some cases obtained by pumping water into a "Differential Accumulator." This may either be done by a pumping engine similar to those described at p. 4, for hydraulic cranes, or by a set of pressure pumps driven by a strap from the shop shafting. This latter plan will often be the most convenient where a stationary engine is already in use for *other purposes.*

The pressure used is 1500 pounds per square inch in this country, but in all machines used on Mr. Tweddell's system in America, the pressure employed is 2000 pounds per square inch.

Drawing No. 56 shows an elevation of a differential accumulator, half in section. The water is pumped in at *a*, and passes into the moving cylinder, B, by the holes, C. The cylinder then

rises, owing to the pressure exerted on the shoulder formed by the difference of diameters of the spindle, D D, at C. Any required pressure is obtained, according to the number of weight rings, W W, put on. The water passes to the machines through outlet, E. Suitable valves are fitted, not only to prevent accidents from too much water being pumped in, but also to automatically stop the pumps, whether driven by belting or separate engines, when the accumulator is filled. Other ordinary forms of accumulators, similar to those used for cranes (see p. 4) can be used when a complete shop is fitted up on the hydraulic system, or for working flanging machinery, etc.

There is little reason to doubt, from the results obtained in practice, that, in a complete hydraulic workshop, only about $\frac{1}{3}$ to $\frac{1}{4}$ of the boiler power would be required as compared with that necessary where ordinary steam or geared machinery is used, and even better results when compared with the system of separate steam cylinders attached to each machine. The loss of useful effect between the pressure pumps and the accumulator has been shown by experiment not to exceed $3\frac{1}{4}$ to $4\frac{3}{4}$ per cent.

The loss by friction in the accumulator is only 1 per cent., and taking the friction at the machines themselves, which does not exceed 1 per cent. also, we have only 2 per cent. total loss from friction in the machines.

The Power absorbed by shafting has been shown by experiments in a length of 1200 feet of, say, $2\frac{3}{4}$ inches in diameter, *with all the straps off*, to be about one horse-power indicated for every 100 feet of shafting. If to this is added the friction of the belts and the gearing of the various machines, it will be seen the loss of power is much greater by shafting and gearing than in the direct application of hydraulic power transmitted from a distance through mains. Another interesting fact is that, in consequence of the motion of the hydraulic machine being least when giving off the greatest pressure, the speed of the water in the main is at its slowest, and therefore the friction is least.

In addition to the above considerations, the hydraulic system must be credited with all the economy obtained by the saving it effects in expensive roofs and walls, required *not* so much for shelter as for carrying shafting and pulleys; the

absence of all foundations; and also the saving in head room, and the consequent greater facility of working cranes, etc., owing to clear headway. There is again a great saving in shop floor room, and in boiler and ship yards where much rivetting is done, the portable riveters, by enabling the work to be quickly turned out, make a small ground area as productive as a large one not so fitted.

Rivetting Machines, Stationary.

In these machines the closing pressure upon the rivets is capable of adjustment, according to the requirements of the work. The pressure brought to bear on the rivet combines the effect of a blow and also a steady squeeze or pressure, which pressure can be retained as long as desired. This property is also taken advantage of to lay the plates together before rivetting, thus saving much heating and risk of burning the plates. From 10 to 15 rivets per minute can be closed in boiler work, and for girder work a considerably greater speed can be obtained.

The force used varies from 25 tons to 50 tons closing pressure upon the rivet-heads. In practice it is found that 40 tons can do any work up to 1¼-inch rivets in 1¼-inch plates.

The latest form of this machine is shown at Drawing No. 57. As will be seen, the cupping die is flush with the top of the cylinder, thus enabling the rivets in flanges and angle irons on flat surfaces, and the throats of locomotive fire boxes to be readily reached. In this case the cylinder and gear are all *above ground*, and the action is *direct*—a great point, if it can be managed. As a rule, the hob, or dolly, should be of steel or wrought iron, to allow of small flues being got over it for rivetting. The stroke of the dies is such that if the rivet is too short, the full pressure is given to close it; if too long, no harm comes to the machine, and different numbers of thicknesses of plate can also be rivetted without any special adjustment.

Portable Rivetting Machines.

These machines will close, say, 300 rivets from 1 inch to 1¼ inch in diameter per hour; they are very useful in a workshop, and can either be suspended from special cranes or can be hung temporarily from ordinary cranes over the work to be rivetted.

Drawing No. 58 shows the type of machine first patented by Mr. Tweddell, but with several recent additions in details. It will be seen that it has two levers. The rivet is closed by causing the cupping dies attached to the levers to be brought together. Either end of the lever may be used for rivetting, the other end, of course, acting as the fulcrum In this way *two* gaps are available—one, a short one, capable of closing large rivets; the other doing proportionately smaller rivets at a greater gap. The pressure water is brought through the curved tube by which the machine is suspended. This combination of suspending gear and pipe is used in several forms; it simplifies the tackle about the machine, and allows it to assume various positions without breaking any joints. This last is a recent addition, and it may here be observed that Mr. Tweddell has frequently acknowledged the valuable assistance he has received in designing new machines on his system (especially for rivetting purposes) from Mr James Platt and Mr. John Fielding, and indeed many of the machines about to be described are jointly patented.

Work done—In bridge work, about 2000 rivets per day can be put in on straight girders, as many as 5000 rivets have, however, been put in by one machine in ten hours.

In wagon work, rivetting the frames of wagon bodies at works in Scotland, 2100 rivets have been closed per day by one poi table rivetter.

Drawing No. 59 shows a machine designed for rivetting locomotive fire doors, angle iron rings for marine and land boiler fronts, furnace rings and lattice girders. The rivetter proper, R, is free to revolve inside a sleeve or strap, A, and when the holder up end, R_2, is placed inside a locomotive fire box, the man has nothing to do, when the fire hole door is circular, but turn it round on its centre, thus closing the rivets in its circumference consecutively, and, if oval or square, it can do them also with a very slight adjustment of the lifting tackle. This machine, being direct-acting, can be made very powerful for small gaps, and can close large rivets.

In locomotive shops, as many as ten rivets per minute have been put in foundation rings by these portable riveters, the rivets being $\frac{7}{8}$ inch in diameter and through a total thickness of copper and steel of $3\frac{3}{8}$ inches.

Drawing No. 60 shows another form of portable rivetter, suitable for boiler flues, bridge work, girders, tender tanks, and work where a long gap is desirable. Most of these machines range from 3 feet to 4 feet 6 inches gap, and are specially designed for lightness; otherwise their principle of working is the same as older types of fixed rivetters.

These machines can be suspended from overhead travellers, or a fixed crane, as shown at Drawing No. 61. The suspending gear is so arranged that they can hang with their levers either in a vertical (as illustrated) or a horizontal position.

The cupping dies of these machines can also, when necessary, be made flush with the top of the cylinder (see Drawing No. 61, showing one suspended to a crane), in which case, as shown at Drawing No. 60, the cupping dies, A B, can rivet angles, etc., on flat surfaces, without the outer radius of the cylinder, C, coming in the way.

Drawing No. 62 shows a form of portable rivetter, which enables the cylinder to be removed altogether from the ends of the levers carrying the cupping dies. This, of course, enables more work still to be reached.

It is true that in Mr. Tweddell's first patent (see Drawing No. 58), the cylinder is out of the way also, but when the gaps come to be considerable, this form of machine, owing to its having two powers (and in consequence two gaps), becomes too bulky, and without sufficient compensating advantages. It is, then, better to dispense with this double action, and, by adopting another order of levers, sacrifice the use of the other end of the levers for rivetting, and place the cylinder there.

The most recent arrangement is shown on Drawing No. 62; great simplicity and stiffness have been obtained by adopting the radial cylinder and ram, as shown in the drawings. This type of machine has been used successfully for ship's stringers, floors, and similar work, and proved perfectly rigid and stiff up to 4 feet 6 inches gap, and while only weighing from 25 to 30 hundredweight; is capable of closing rivets 1 inch in diameter.

The cylinder, it will be seen, has its longitudinal axis coincident with a radius struck from the centre of oscillation of the levers. All connecting rods, etc., are thus dispensed with, and since the rams on the one lever, and the cylinder on the others, practically form part of their respective levers,

the whole machine is perfectly rigid—a very important consideration towards securing fair and sound work.

There are many other different kinds of rivetting machines made under Mr. Tweddell's system, but it is unnecessary to particularize them, their number and variety only proving the applicability of hydraulic pressure to this class of machine tools.

The application of portable machines, however, would be comparatively limited were there not also sufficient means of taking or applying the machines to their work, so as to do away with manual labour in this work also. For this purpose hydraulic power is, perhaps, in its best field, and by the use of hydraulic lifts (which not only do the lifting and lowering, but also serve to conduct the pressure to the tool), two purposes are served—first, the size and consequently the capacity for work of the machine is no longer limited by the weight which men can handle, and all pipes hanging about in the way are avoided.

Hydraulic (Fixed) Crane and Lift.

Drawing No 61 shows one of the numerous types of these cranes. A vertical lift of from 4 feet to 6 feet is obtained by means of the hydraulic lift, A, placed between the rivetter and the travelling carriage, B. The carriage travels the whole length of the jib, C, and the rivetting machine, D, can be racked in and out, without disconnecting the pipe joints. A crane fixed in the wall, and having 28-feet rake, can rivet any work placed within an area of 1200 square feet.

Very large and heavy machines can, on this plan, be used as portable tools, since all the raising and lowering is done by hydraulic power. In many cases these lifts are simply suspended from the end of an ordinary travelling crane chain, and in other cases hydraulic travellers are used, each case having to be treated on its own merits.

When no lifts are used, small copper pipes are employed to conduct the pressure water. These pipes are coiled in a spiral form. A spring-like action is thus secured, which allows the rivetter to vary its position within considerable limits; and in practice, the copper piping is found to answer perfectly, and it is not subject to the damage inseparable from the use of india-rubber hose.

In many cases, however, the work to be rivetted is spread over so large an area that a travelling crane is necessary, which is hereafter described.

TRAVELLING CRANE AND LIFT.

Drawing No. 63 shows this crane; it can travel from 20 feet to 30 feet along the ground or the shop floor without disconnecting any pipes, and, with a jib of 28-feet rake, a floor area of 4000 square feet is covered. The arrangement of lift is similar to that in Drawing No. 61. The great advantage of this plan is that the work on girders and similar work can be going on in different stages on either side of the rail on which the crane runs, erecting and plating on the one side, and rivetting on the other; or the crane can be used for plating and erecting first, and rivetting afterwards. Pressure mains are led from the "accumulator," between the rails. The jib in Drawing No. 63 is free to revolve all round. A hydraulic lift, carried on the travelling monkey, not only serves to conduct the pressure, but to raise and lower any weight up to 1 or 2 tons. Two of such cranes are often placed at the head of a ship-building slip, and all the floors and frames rivetted up as they pass under on their way down the keel, across which they are laid for rivetting before being up-ended. As soon as the ship is done, the cranes are moved to the next berth, or in some cases placed inside the hold for rivetting up the floor, etc. Ship rivettings, so far as the shell work is concerned, is a problem yet to be satisfactorily solved; but so far back as 1872, in a paper read before the Institution of Mechanical Engineers, at Liverpool, Mr. Tweddell described his mode of rivetting ships' frames, keels, etc., which is now practically carried out, and used by all leading shipbuilders.

PORTABLE RIVETTING PLANT (Drawing No. 64).

The characteristic of this arrangement is that not only is the rivetting machine carried on a crane, but the motive power for driving it also, and since the waste heat from the rivet-heating furnaces nearly suffices to drive the pumps, it is evident that, so long as the rivets have to be heated, nothing more economical as to cost of working can well be devised.

The object of this design is to meet cases in which the bridge is to be erected in sites where skilled labour is often difficult to

obtain, and much of the rivetting work is very heavy. This plant has not only been considerably adopted abroad, but also used in England. The first bridge, indeed, ever rivetted by hydraulic machines was thus done in London, in 1872, on the Great Eastern Railway Extension Works at Bishopsgate Street. But little description of Drawing No. 64 is required. All the lifting, racking, travelling, and other movements can, if desired, be done by power from the engines which drive the pumps. The accumulator spindle is utilized to serve as a crane post, and all the gear turns round this. The crane jib is made a great height, on account of doing the deepest girders.

Small hydraulic punching, shearing, straightening, and bending machines can readily be attached to the bed plate, and are very useful; of course the pressure is available to work other rivetters, which, for the time being, may be suspended by ordinary tackle on other parts of the work.

Hydraulic Punching and Shearing Machines.

Drawing No. 65 shows a hydraulic punching, shearing, and angle-cutting machine, similar to those supplied to the Toulon Dockyard, and other places by the Hydraulic Engineering Company, Chester, to Mr. Tweddell's designs. The largest sizes hitherto constructed can punch 1¼-inch holes in 1¼-inch plates, and shear plates of 1¼ inch thick at a distance of 5 feet from the edge of the plates. The advantages of this system come out more prominently as the work to be done becomes heavier. When the plates are in the proper position to be punched, the workman admits the pressure; this is entirely under his control, and the punch cannot descend until he is ready.

The pressure cannot exceed the load upon the accumulator; and hence it is immaterial whether there is too heavy a piece of work put in or not, as the machine cannot be strained.

The machine works silently; there is no noise or vibration, and on this account foundations are unnecessary.

As each cylinder with the tool holder attached is independent, an accident to one of them does not cripple the whole machine, as is the case when gearing is used; and as each tool works independently of the other, the man has not to wait until the stroke of the tool at the other end of the machine is completed. Each part of the machine is self-contained, and,

if desired, it can be taken into three parts and placed separately about the yard, or taken to where temporarily wanted, and connected to the mains. The facility for putting on special tools or stamps is also very considerable; and the shear blades are so attached that they can very readily be altered to any angle by moving the blocks which hold them.

The valve gear is arranged so that the amount of water used is proportionate to the thickness of the plate punched. The angle and bar cutter is shown placed between the punch and the shears, but of course the combinations are practically endless. A great incidental advantage is the clear headway obtainable for cranes, owing to the absence of belting or shafting.

Amongst the other different applications may be mentioned the

Chain Cable Shearing Machine (Drawing No. 66).

In this modification of the hydraulic shears just described, the general principle is, of course, the same. The cable, although cut in one stroke, is, by stepping the knife, A, really cut in two efforts, thus allowing the area of the cylinder to be halved, although, of course, doubling the stroke. The same amount of water is therefore used, but considerable structural advantages are secured.

The machine is a double-ended one, and chain cables from ½ inch up to 3½ inches in diameter can be cut without requiring any alteration in the knives.

As in all Mr. Tweddell's machines, the return motion is automatic and effected by hydraulic pressure. These machines are in use in most of the principal public chain-testing establishments in this country, and are worked both by pumps direct and also with accumulators.

Rail Shears (Drawing No. 67).

This illustrates another mode of applying hydraulic power by the use of a steam accumulator. This device has been used for many years, the novelty in the present machine consisting chiefly in the use of an automatic cut-off gear, which it is not necessary to describe in detail here. The principle of the apparatus is this: A large steam piston in the cylinder, A, and

subject to pressure of steam from a boiler, and having a considerable length of stroke, imparts a proportionately intense pressure per square inch on the fluid in the smaller cylinder, B, placed above it. The water in cylinder B being thus under great pressure, is conveyed through a pipe, C, to the hydraulic cylinder D, with a ram carrying the rail shears, E. The ram in cylinder D having only a very short stroke and a considerable diameter, the power stored up in the cylinder B is applied to great advantage.

Without the intervention of this apparatus, it is clear that with the same steam power an impracticable size of shearing ram would be necessary, as the space through which the tool travels is so limited.

The apparatus illustrated in Drawing No. 67 is intended to be carried in parts on railway trucks from one depôt to another, utilizing the steam from the boiler of the locomotive which draws it. All old rails there accumulated are cut up to scrap, and the apparatus then moves on to the next station, and works off the old rails there.

Stamping, Corrugating, and Forging Presses (Drawing No. 68).

This press is used for corrugating sheet iron or steel plates for roof-work, and also as a stamping machine for fence pillars, footsteps, etc.

It will corrugate plates 12 feet wide by $\frac{1}{16}$ inch to $\frac{1}{4}$ inch thick, and could even take in larger sizes. This class of machine only shows one of the many applications of hydraulic power. The well-known "Mallet" buckled plates have for many years been so manufactured, and similar machines have been made for stamping plough breasts and shares, and in fact shaping and moulding all descriptions of work. It is impossible to illustrate all these various applications, more especially as very often the chief points of interest centre in the ingenuity displayed in the construction of the necessary moulds and blocks.

Disc railway wheels, threshing machine drum-heads, are also so stamped.

Carried a step further, these machines develop into forging presses, and very good work has already been done in this way.

Bending and Straightening Machines.

This is another useful class of machine, and although hydraulic power obtained by means of a hand pump has often been used for this work, the machine shown in Drawing No. 69 possesses some novel features in addition to the quickness of working, due to the use of an "accumulator." The length of stroke of the ram, A, is regulated by means of tappet gear, B, and of course by the same means it can be kept uniform for any work where much repetition is required. The outer abutment blocks, C C, it will be seen, are moved towards and from each other by means of a right and left handed screw, D D, thus keeping their positions relative to the moving block, E, on the ram, A, correct, and capable of adjustment to the greatest nicety. By means of a coupling on the centre of screw at H, each side may, if required, work independently. No breakages can occur should too heavy a beam be put in, as the pressure due to the accumulator cannot be exceeded, and as these machines are made to exert a pressure varying from 10 tons to 100 tons, all classes of work from small angles $4\frac{1}{2}$ inches by $4\frac{1}{2}$ inches by $1\frac{3}{4}$ inch up to I section of the largest sizes rolled, can be bent or straightened.

Flanging Machine.

Drawing No. 70 shows one of Piedbœuf's machines, which is capable of flanging plates of all forms. These presses have been made powerful enough to flange steel plates $1\frac{1}{4}$ inch thick and 8 feet in diameter. The mode of working is as follows. The ram, A, in the main cylinder, A_2, carries a table, B, on which is supported a hollow matrix, C, made of suitable form to pass over a fixed die or block, D, but leaving enough space between their respective surfaces all round to enable the plate, E E, to be moulded. The action is a somewhat peculiar one, since the matrix, C C, passes beyond the block, D, leaving the plate on the latter. This being left still hot, easily falls off by its own weight, and is removed. There is, however, a very important matter to be attended to, namely, holding the plate firmly to the upper block, while the matrix, C C, is passing over it.

The four small cylinders, H H, carry a flat table, I I. This

table being held firmly against the top block, D, with the plate between them, prevents any buckling of the latter.

Very great speed is obtained in working by these presses; in some agricultural workshops as many as 100 smoke box end plates have been flanged in nine hours, and a large plate for the back end of a marine boiler combustion chamber in one minute and a half from the time of opening the furnace door to the plate being levelled and finished.

All the applications of hydraulic power referred to in this article have been confined to machines having a reciprocating action, and, as a rule, exerting a great pressure through a small distance; but there is little reason to doubt that, from the very favourable results already obtained at Toulon Dockyard and elsewhere, there is an ample margin to allow of even rotary and other motions being economically performed by hydraulic pressure.

The simplicity and efficiency of the three-cylinder hydraulic engines of Mr. Brotherhood have already caused them to be thus used for capstans in large iron working shops; and there is probably a large field for the use of such machines in connection with bringing heavy work to machine tools. Mr. Tweddell has suggested their use for working the lifts for his fixed rivetting machines, and in some cases to use them for driving heavy rolls or lathes.

In conclusion, the author cannot too highly recommend this system to the consideration of manufacturers, as the most efficient and economical plant for the purposes named herein.

He considers a wide field is open for the application of the system, and he doubts not that, in a short time, no well-arranged iron-working establishment will be considered complete without such machinery. The author also considers this class of machinery is one of the most ingenious and useful applications of the hydraulic power system; and as the work turned out is so good, Mr. Tweddell is to be congratulated upon his success in the field he has made his own, almost without a rival.

ADDENDUM.

Clark and Standfield's Hydraulic Lift for Railway Trains.

Since Part I. of this book has been in type, the author has been favoured, by the above firm, with a drawing and description of a novel application of their patent hydraulic system, which may probably solve a difficult problem in railway work, especially in the vicinity of large towns, or where the trains of different companies may arrive at the same point at high and low levels. Much saving of time and cost would be effected by the proposed plan, which also has the advantage of being perfectly safe, free from all complication in working, and also a very economical application of power.

A large amount of money has been wasted in forming inclines, which are very expensive and dangerous to work, and require excessive engine power.

This is illustrated by the approaches to the Thames Tunnel; the Ludgate Hill Station; and the high-level stations of the London, Chatham, and Dover Railway; the Snow Hill incline, and many similar places.

This evil may be entirely obviated by the hydraulic system of balancing one train against another, or preferably by balancing the train by a differential compensating accumulator, with automatic valves, to ensure the horizontality of the system.

Such a system, designed by Messrs. Clark and Standfield, is illustrated in Drawings Nos. 71 to 73. Drawing No. 71 shows a side elevation, Drawing No. 73 an end elevation, and Drawing No. 72 a plan of a hydraulic train lift (which may be made of any length), suitably guided and supported on a number of presses. The trains are balanced by a differential compensating accumulator (not shown in the drawing), on the system de-

scribed before; so that the train or accumulator may be made to preponderate, and be raised or lowered at will. The train is kept level by automatic valves, as before described. When the height is moderate, this operation may be easily performed in less than one minute as in an ordinary passenger lift.

Before the train descends, the opening is protected by powerful hydro-pneumatic buffers, as in the Drawing, which shows one in position, and one swung back. Similar buffers are provided at both ends of the lift. This system could be cheaply and readily applied both to tunnels and high-level bridges, and would be very suitable for river ferries. By a similar compensating system applied to balancing platforms for railway passengers, a railway tunnel might be constructed in the London clay at a low level beneath streets and houses, without interfering with any surface property, except at the stations, the trains being raised to the high-level systems when outside the city area.

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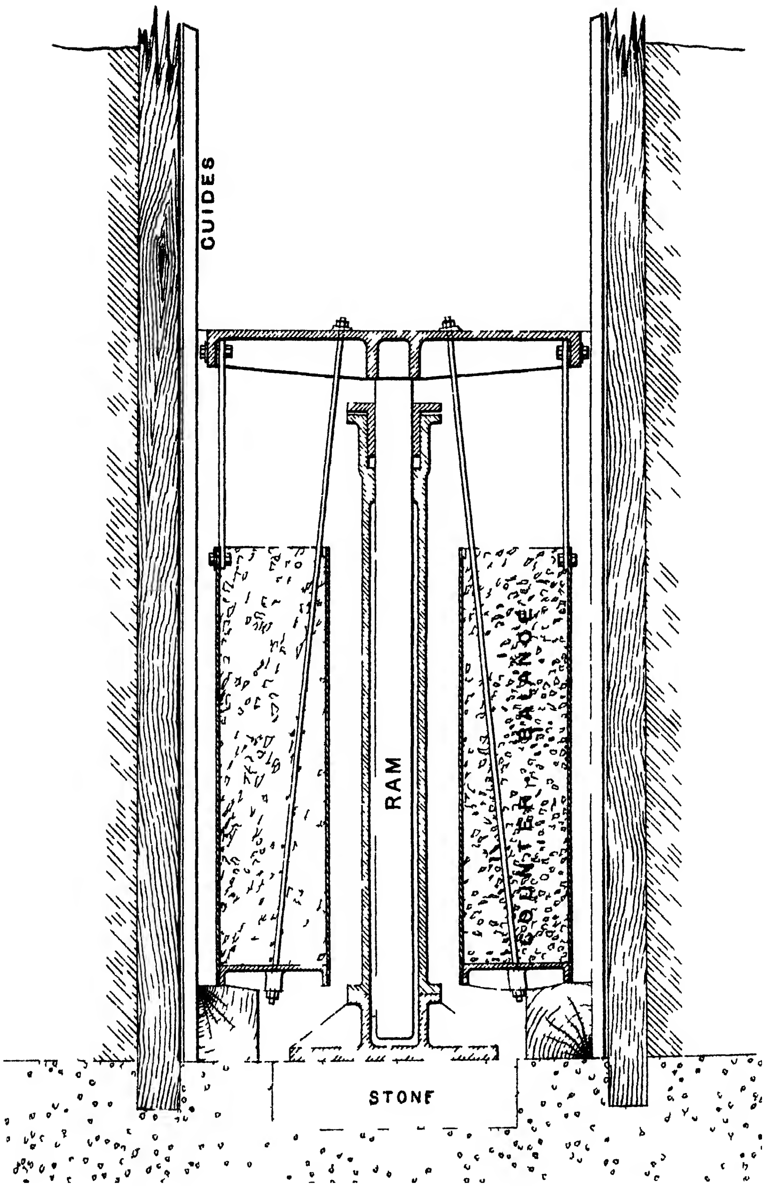
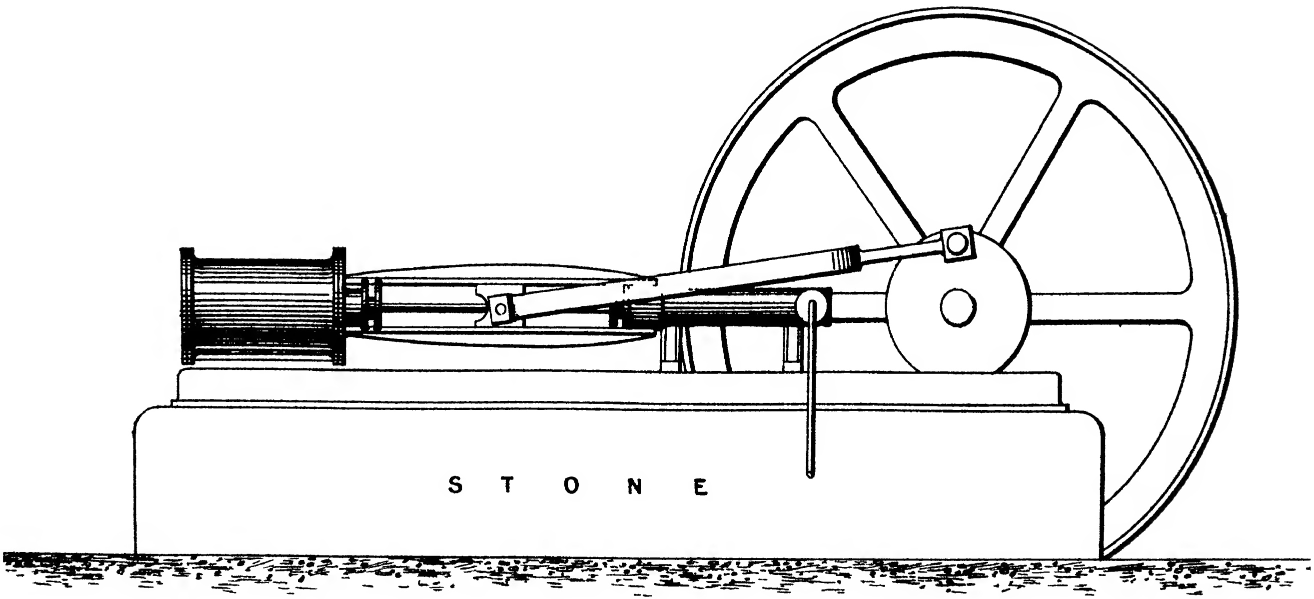
ACCUMULATOR



PUMPING ENGINE.



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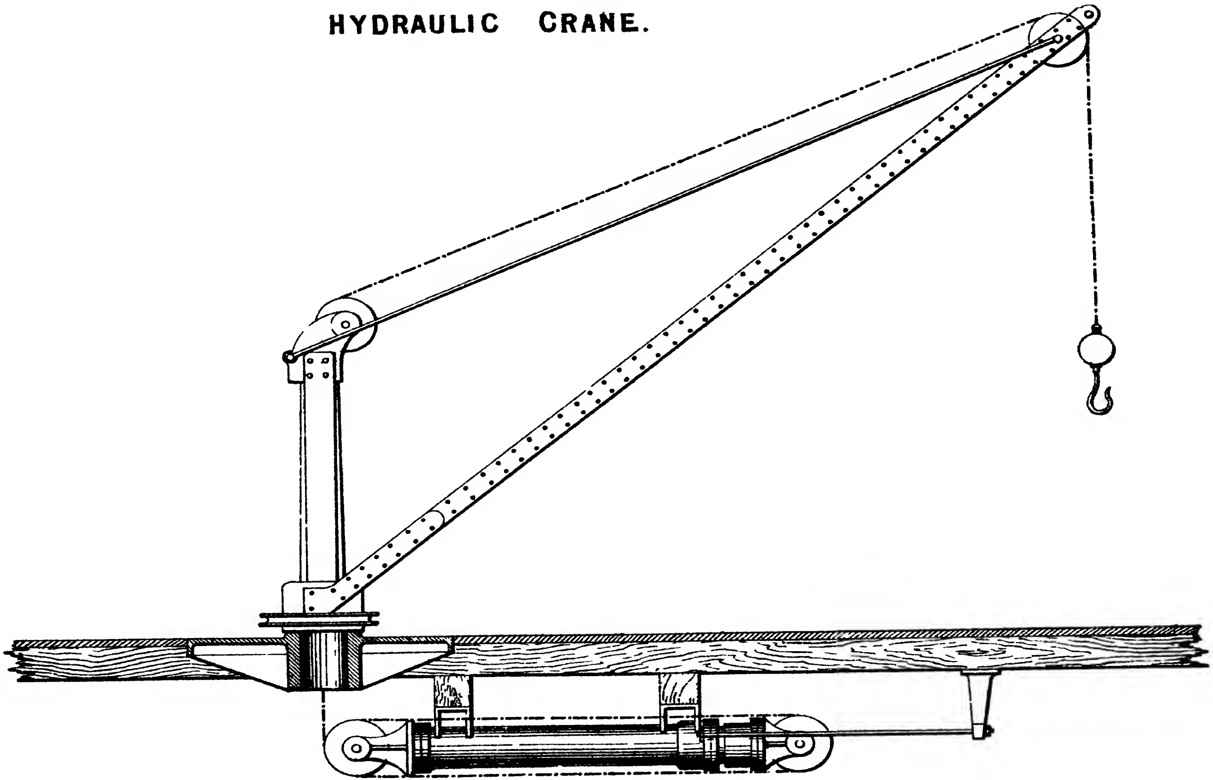

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No 4.

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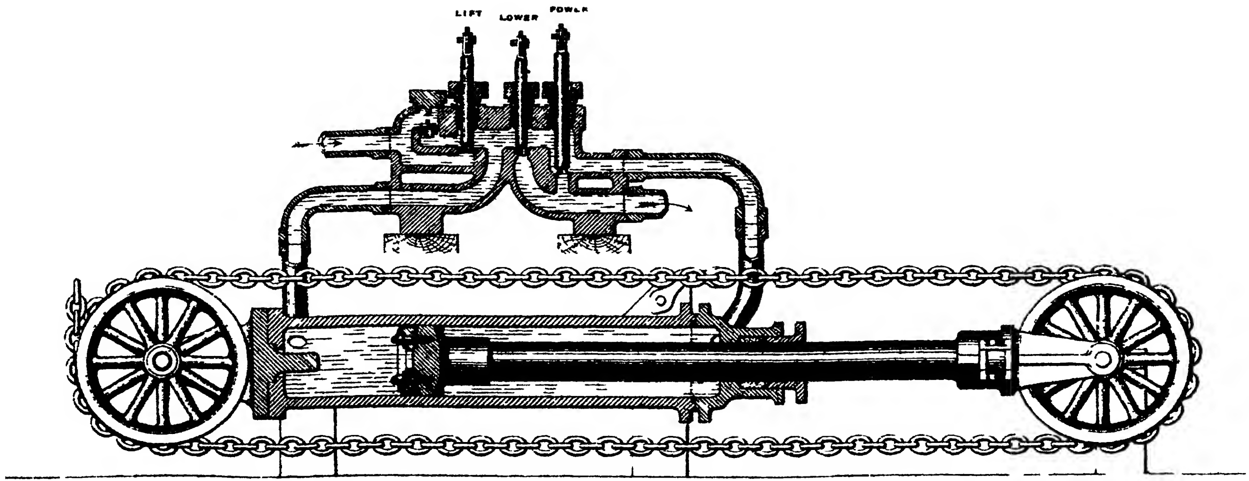

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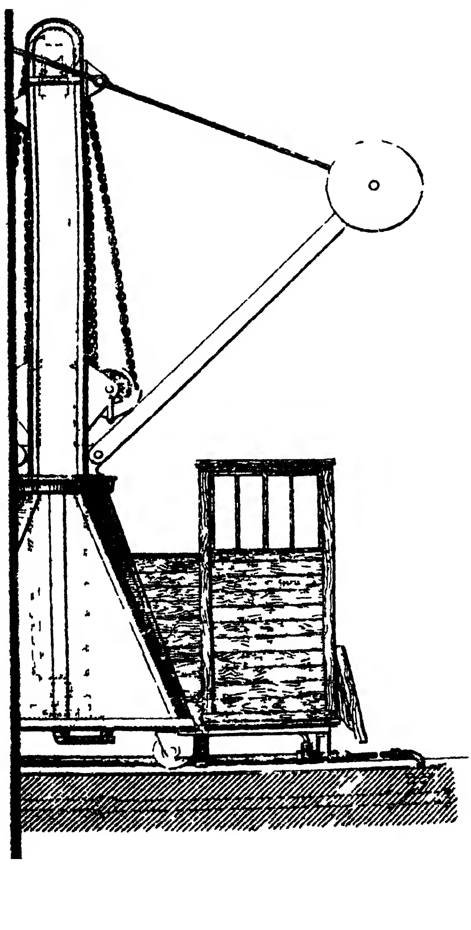

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ELINGTON'S PATENT MOVABLE HYDRAULIC WINCH
WITH
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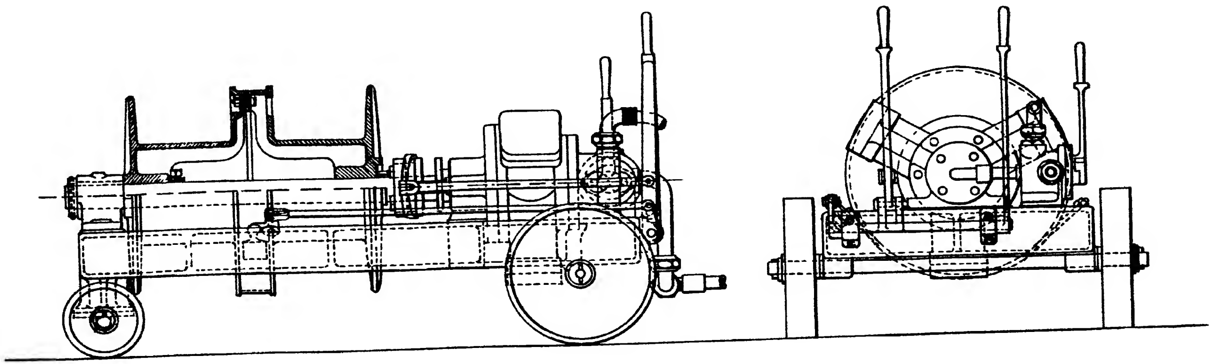

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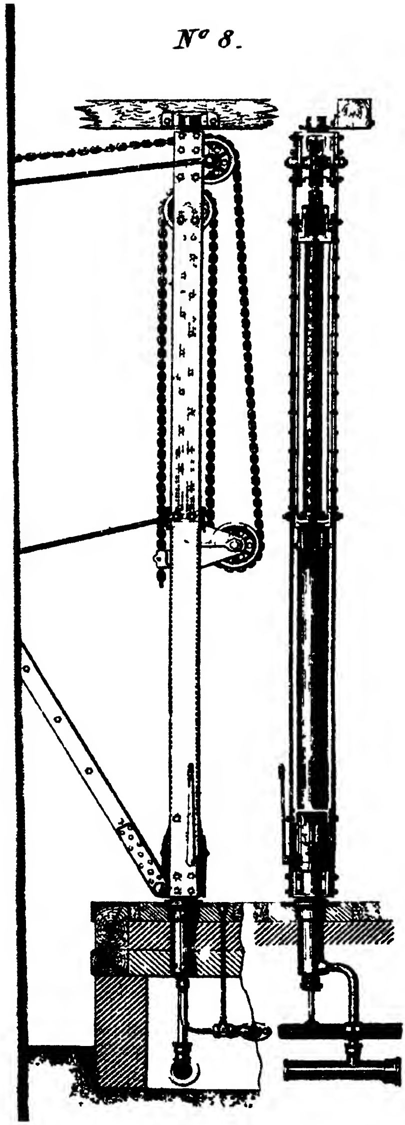

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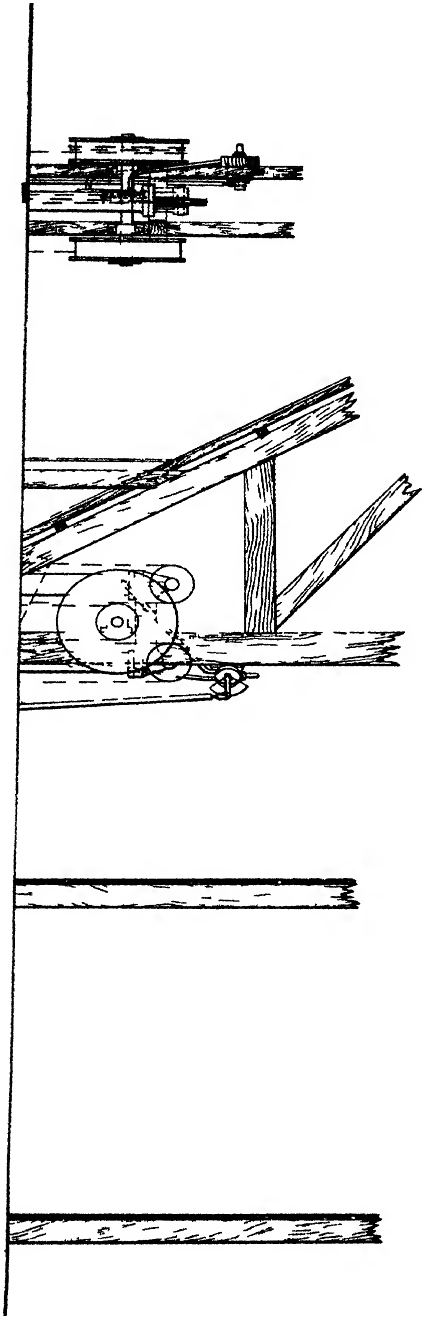

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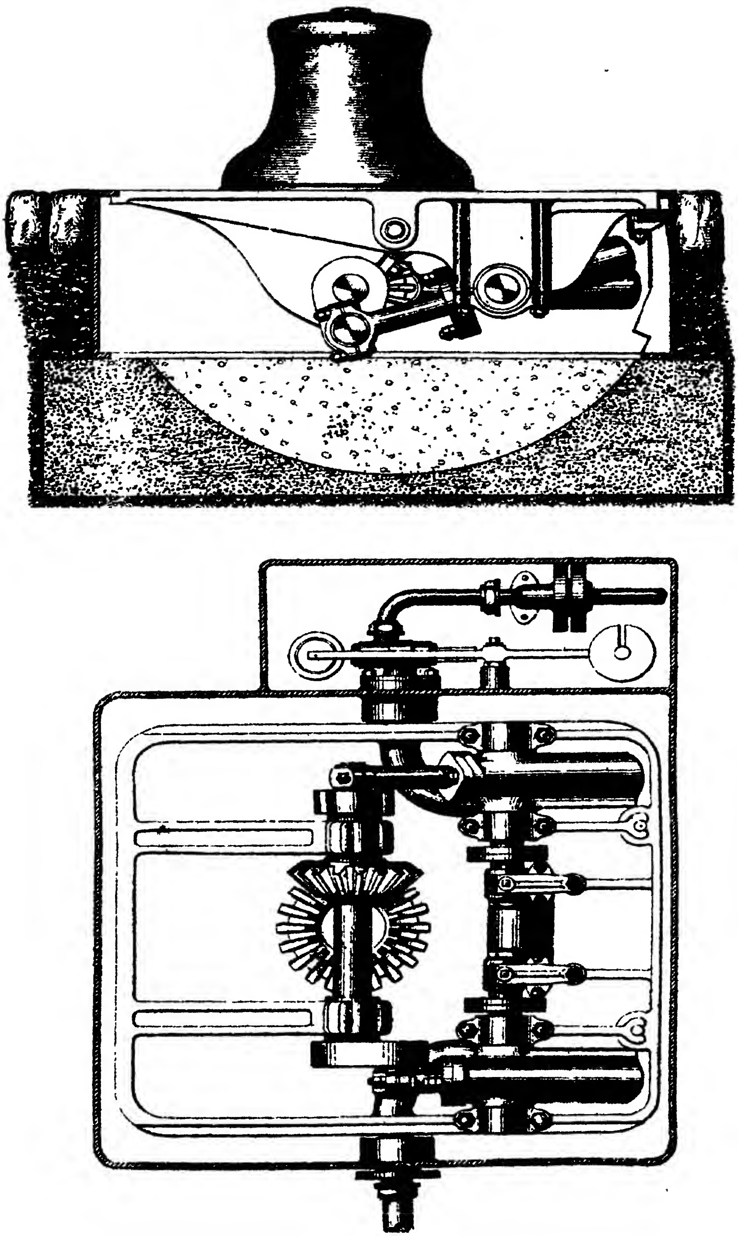
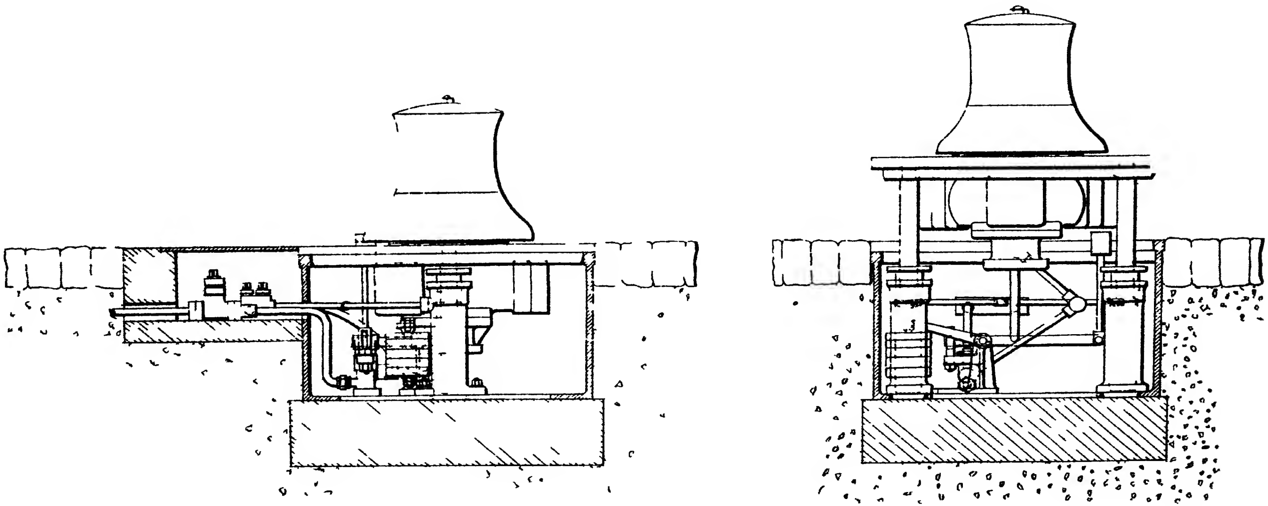


3 CYLINDER HYDRAULIC CAPSTAN.

ELLINGTONS PATENT



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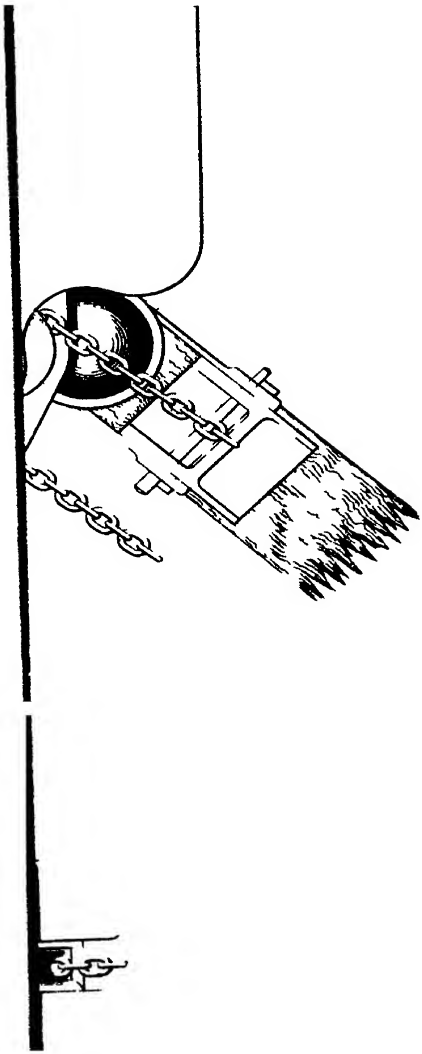

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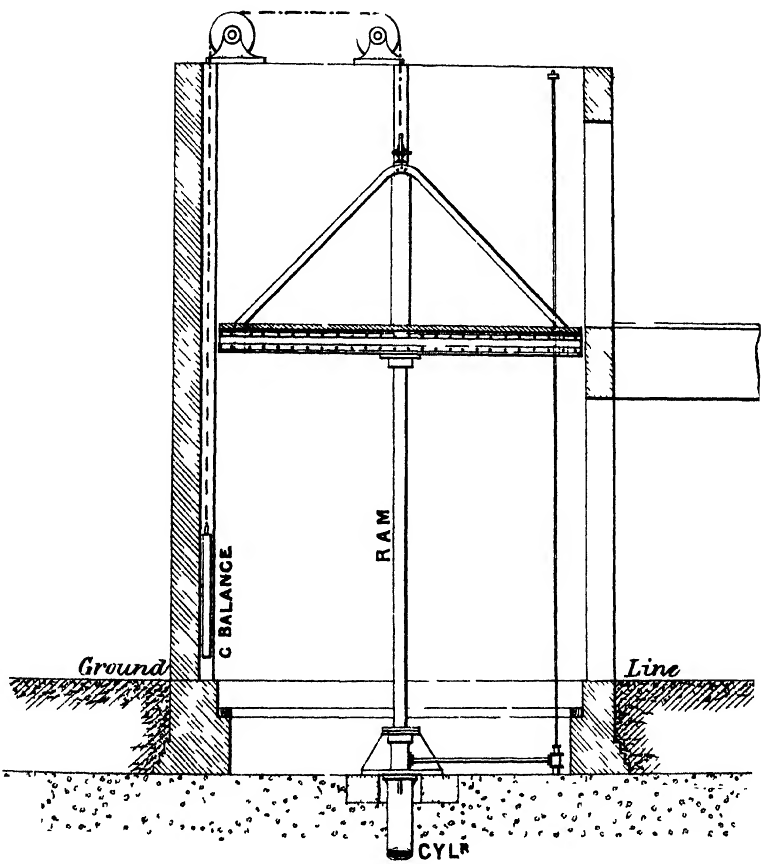

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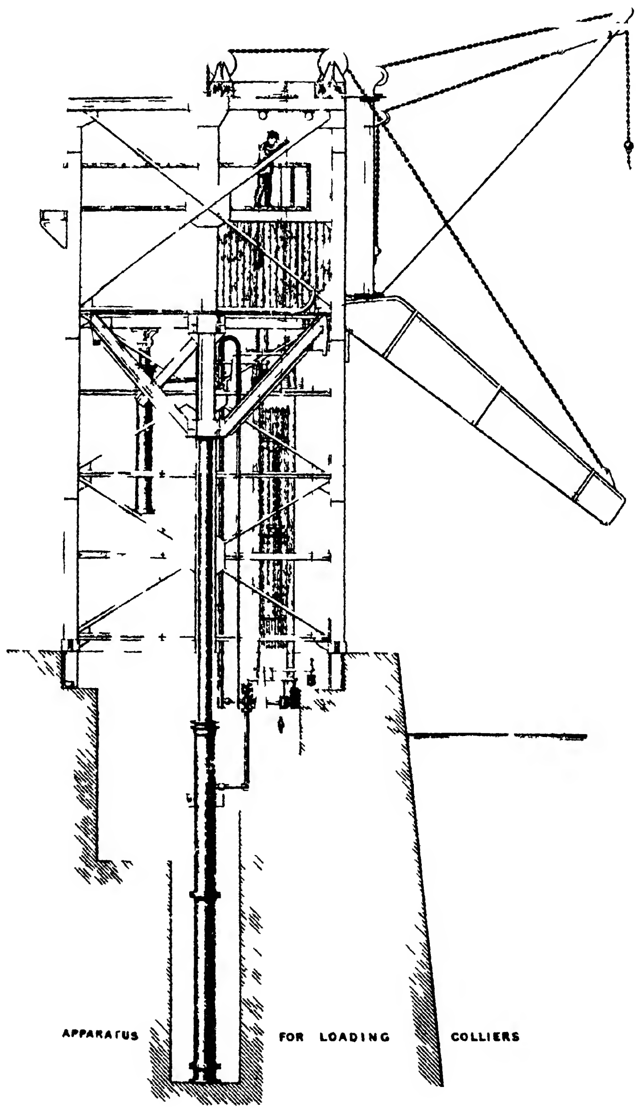

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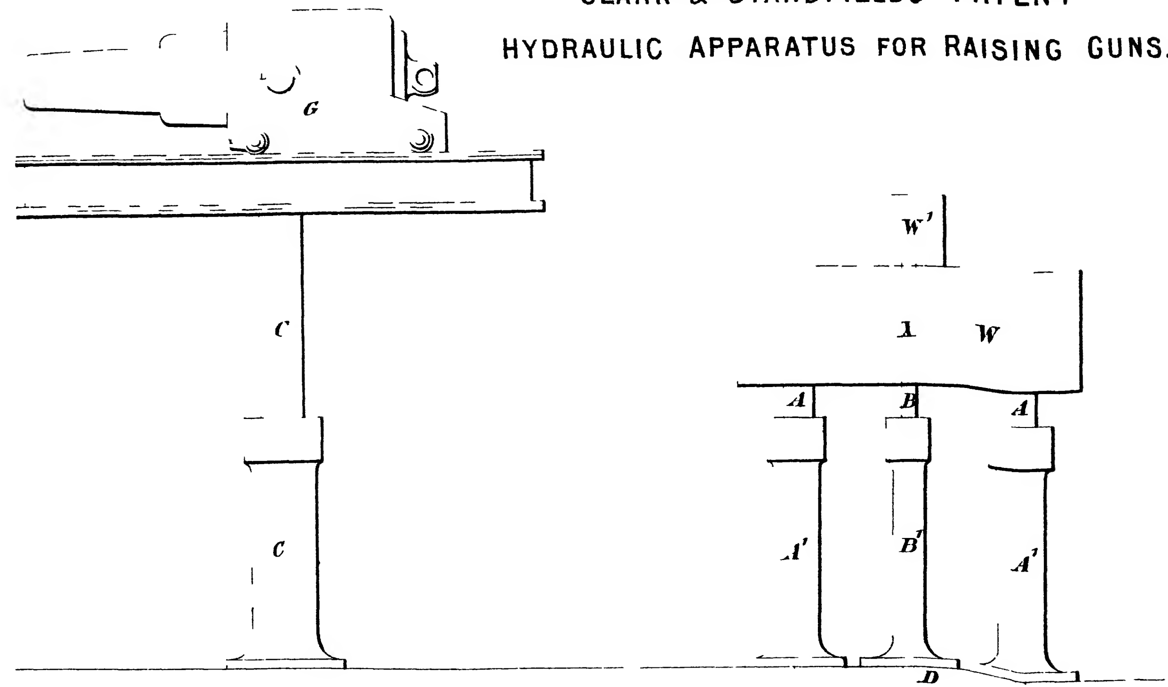

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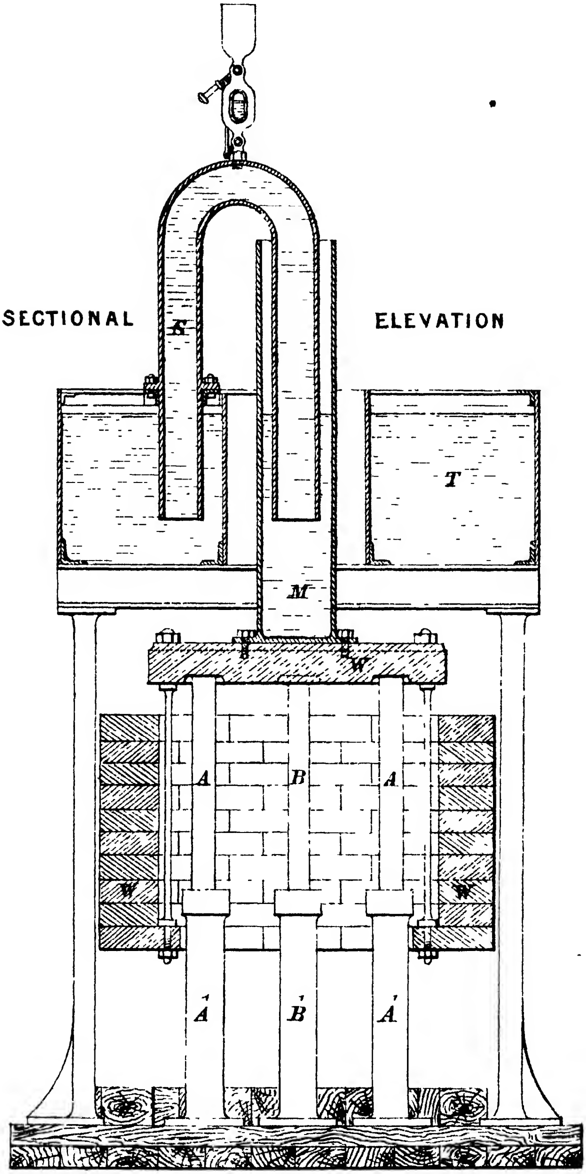

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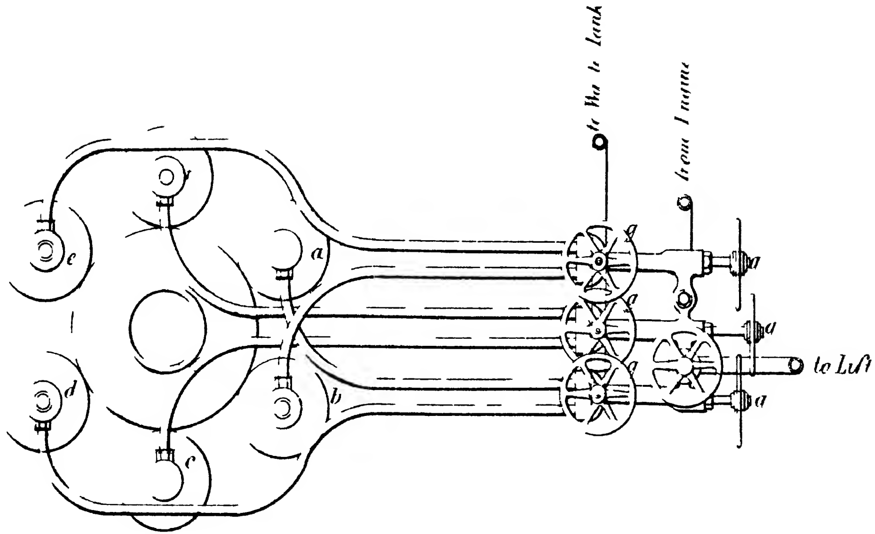

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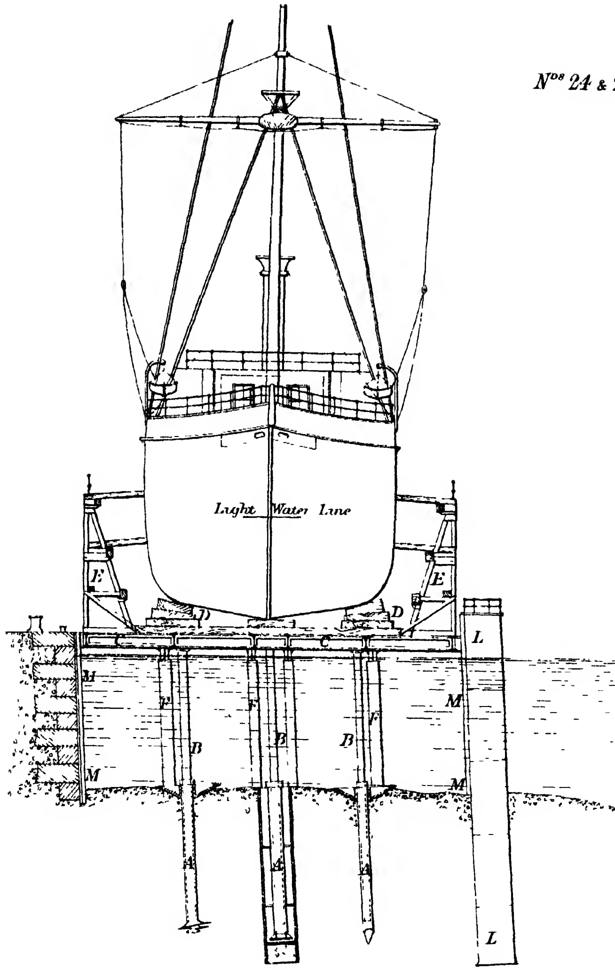

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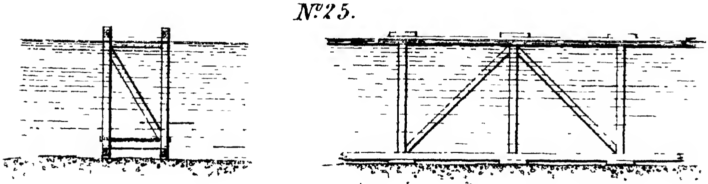

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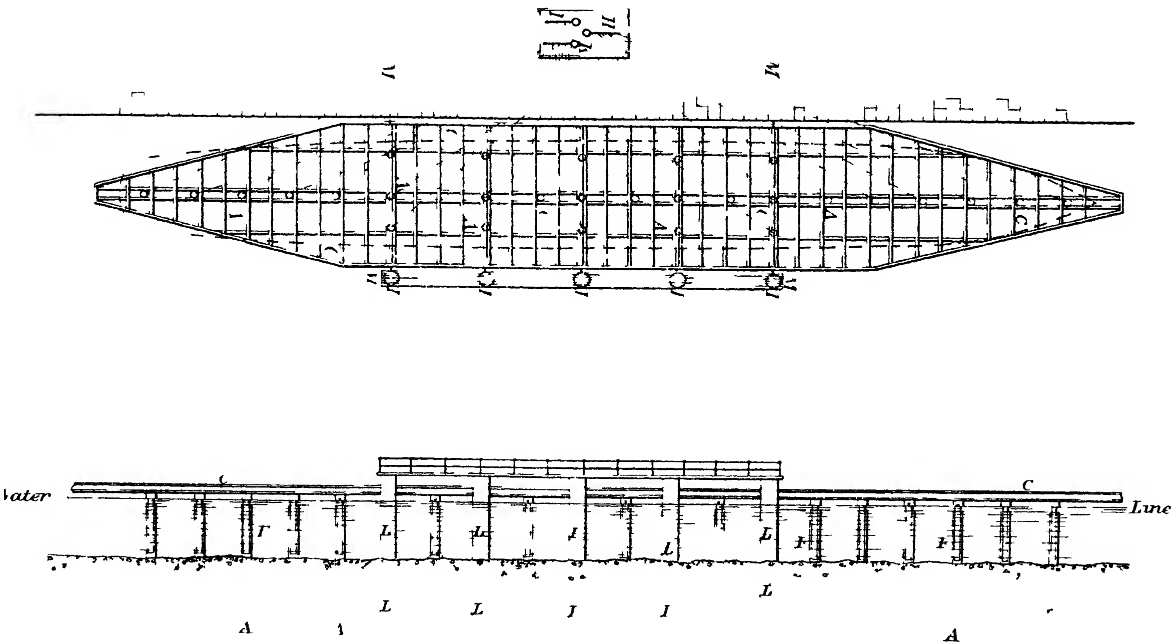

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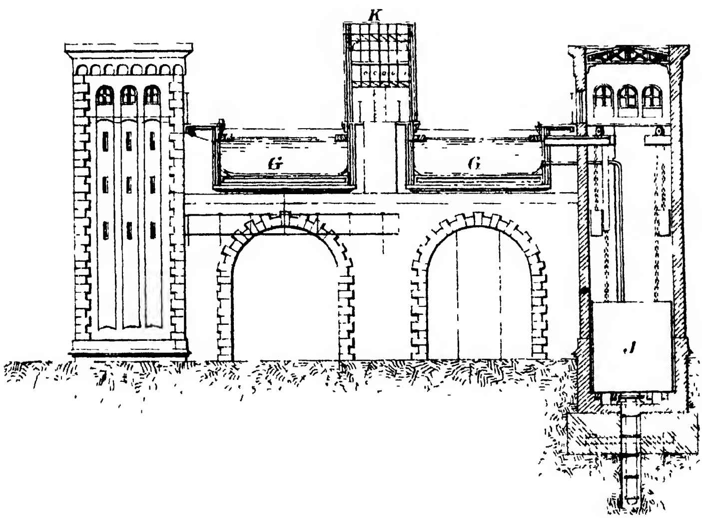

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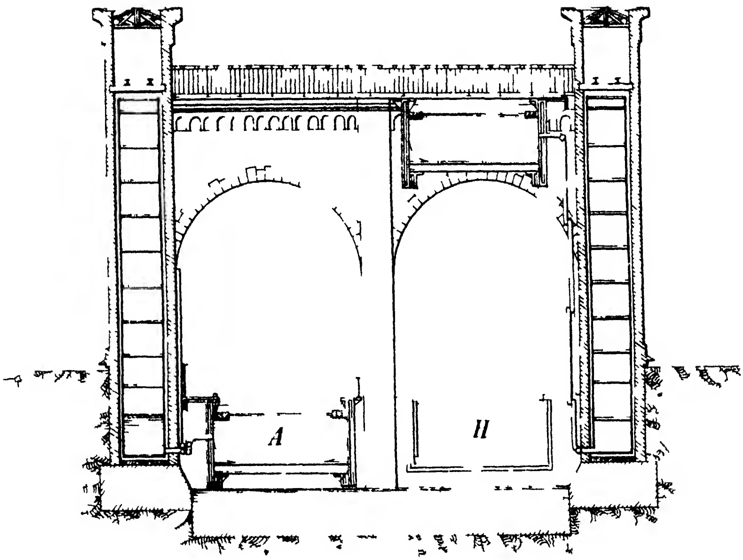

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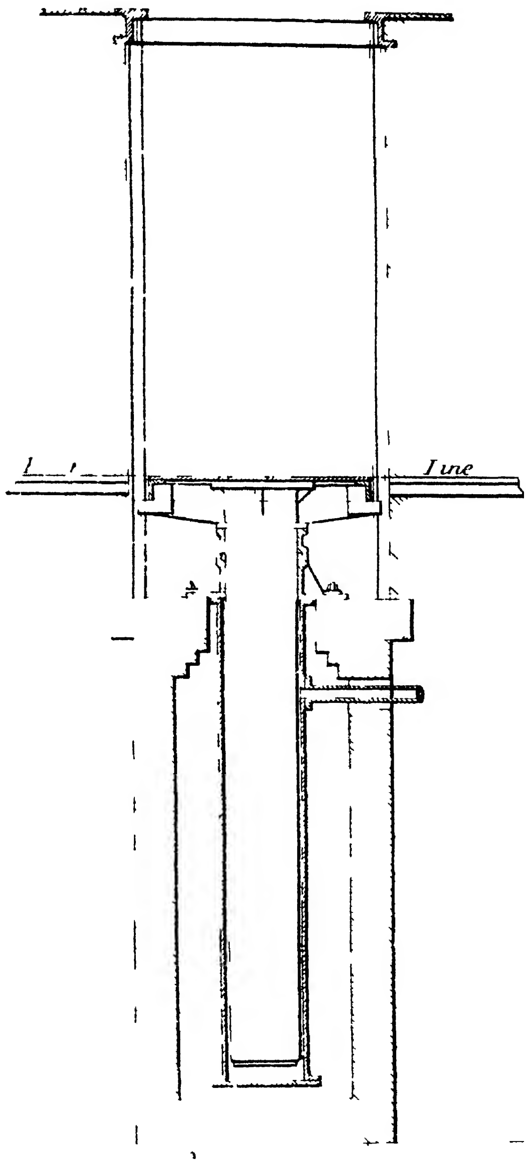

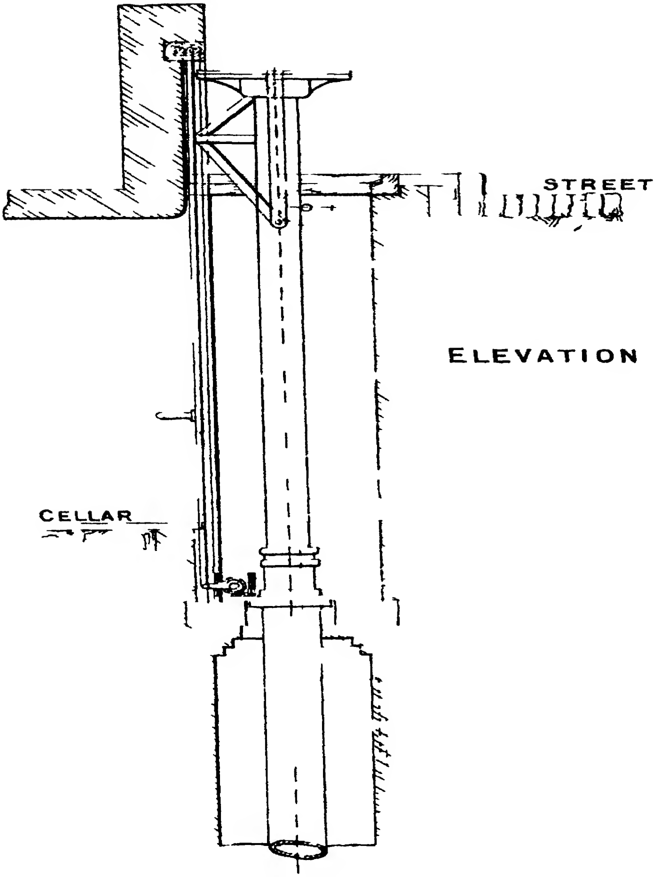

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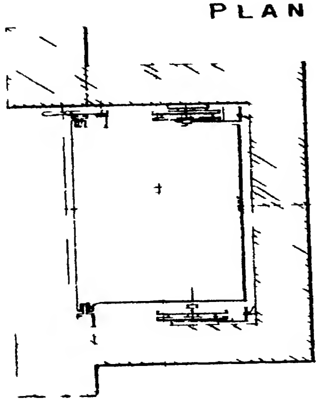

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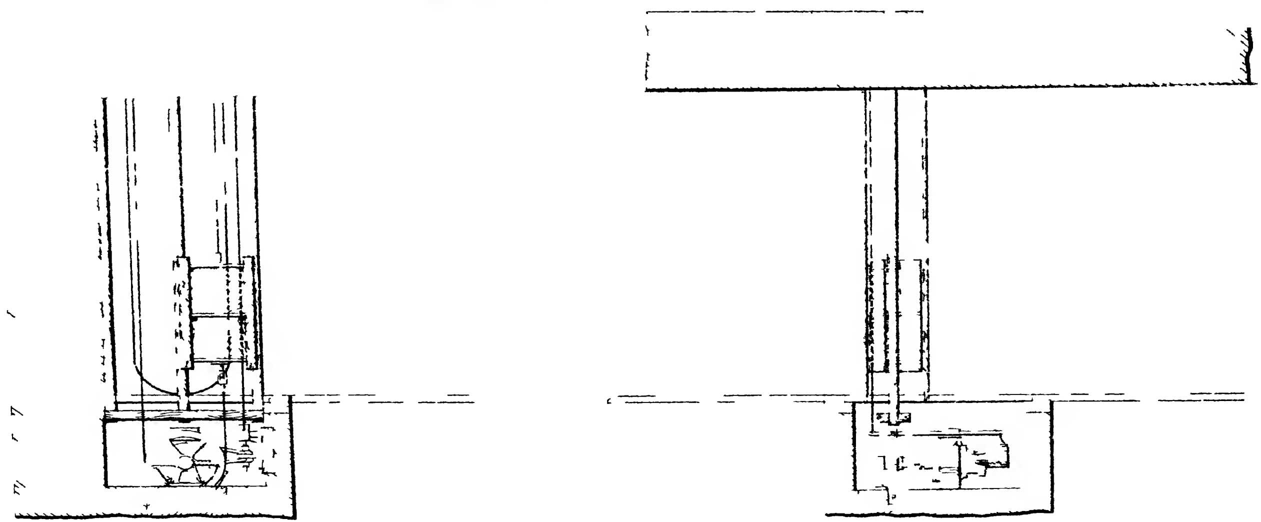

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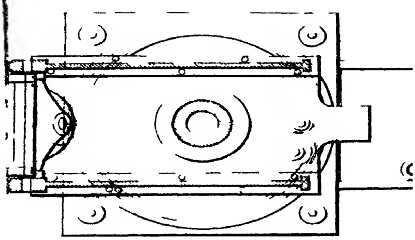
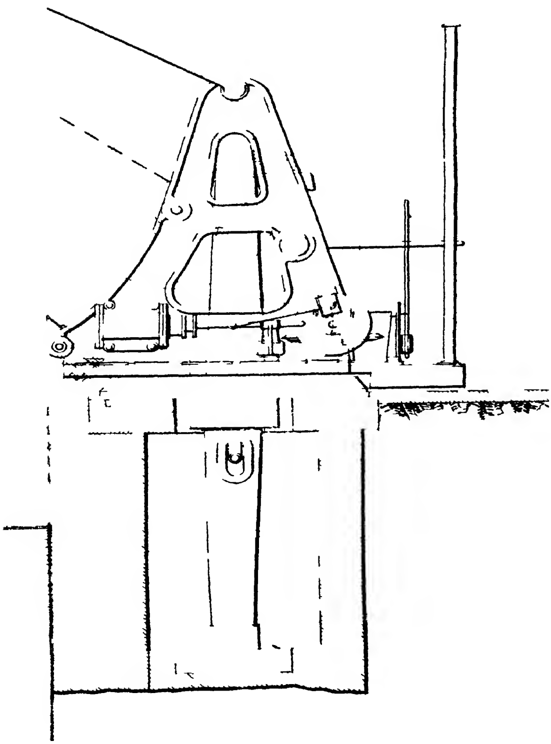
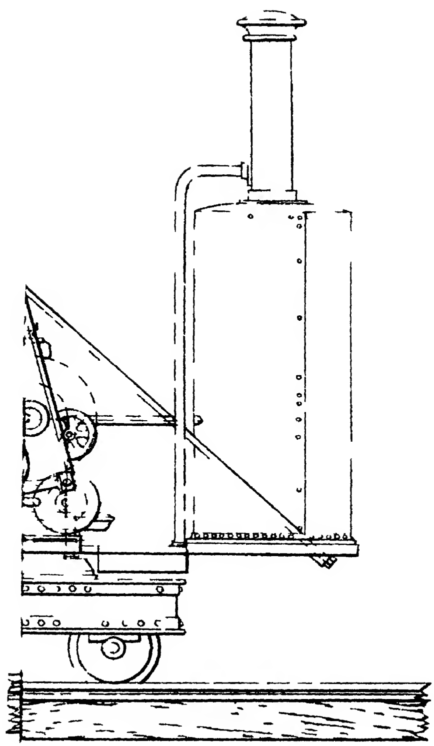
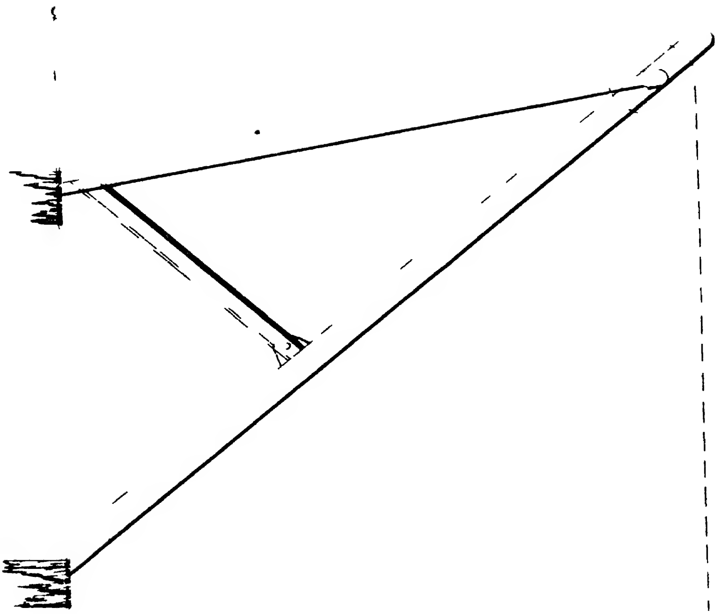






|ANE & HOIST.



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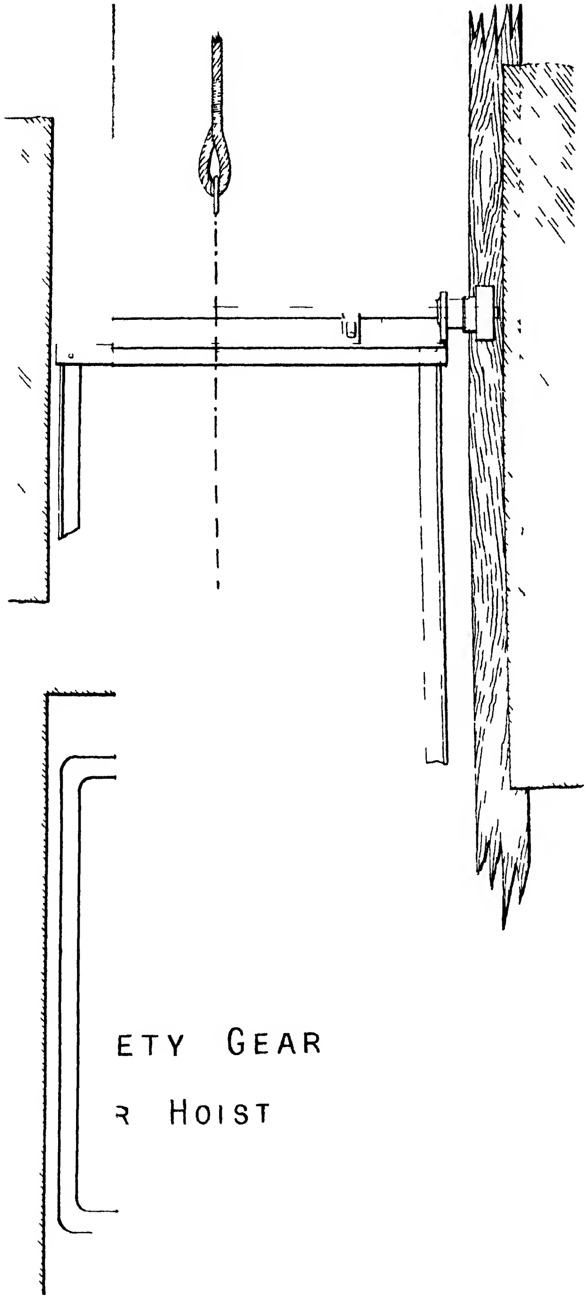

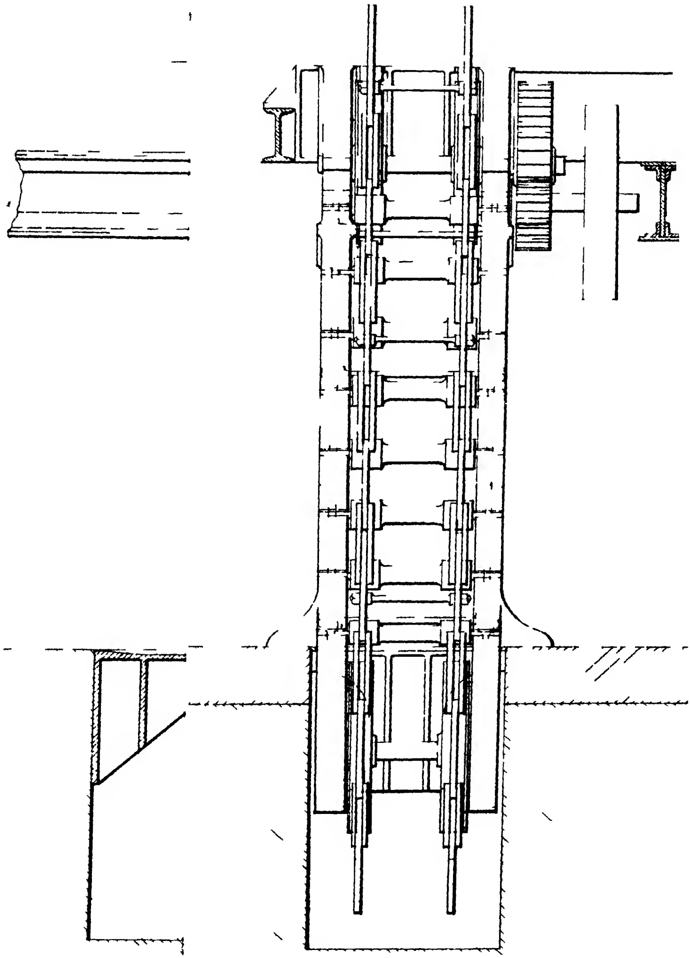

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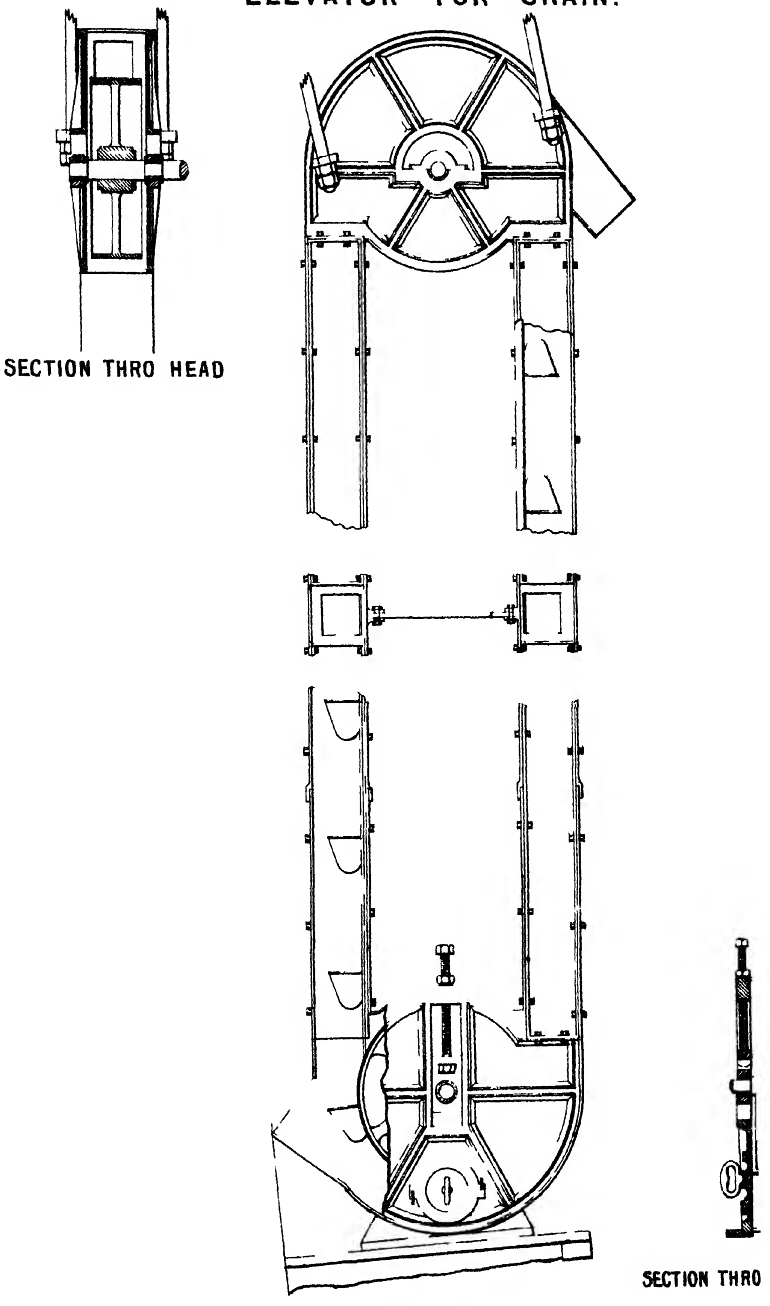
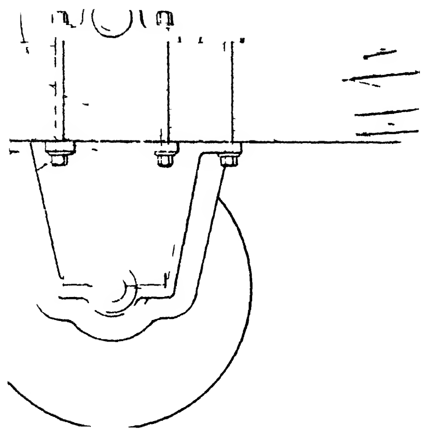
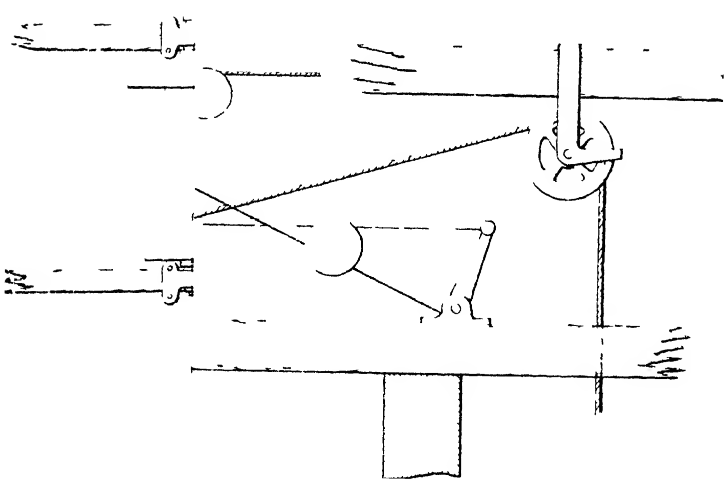
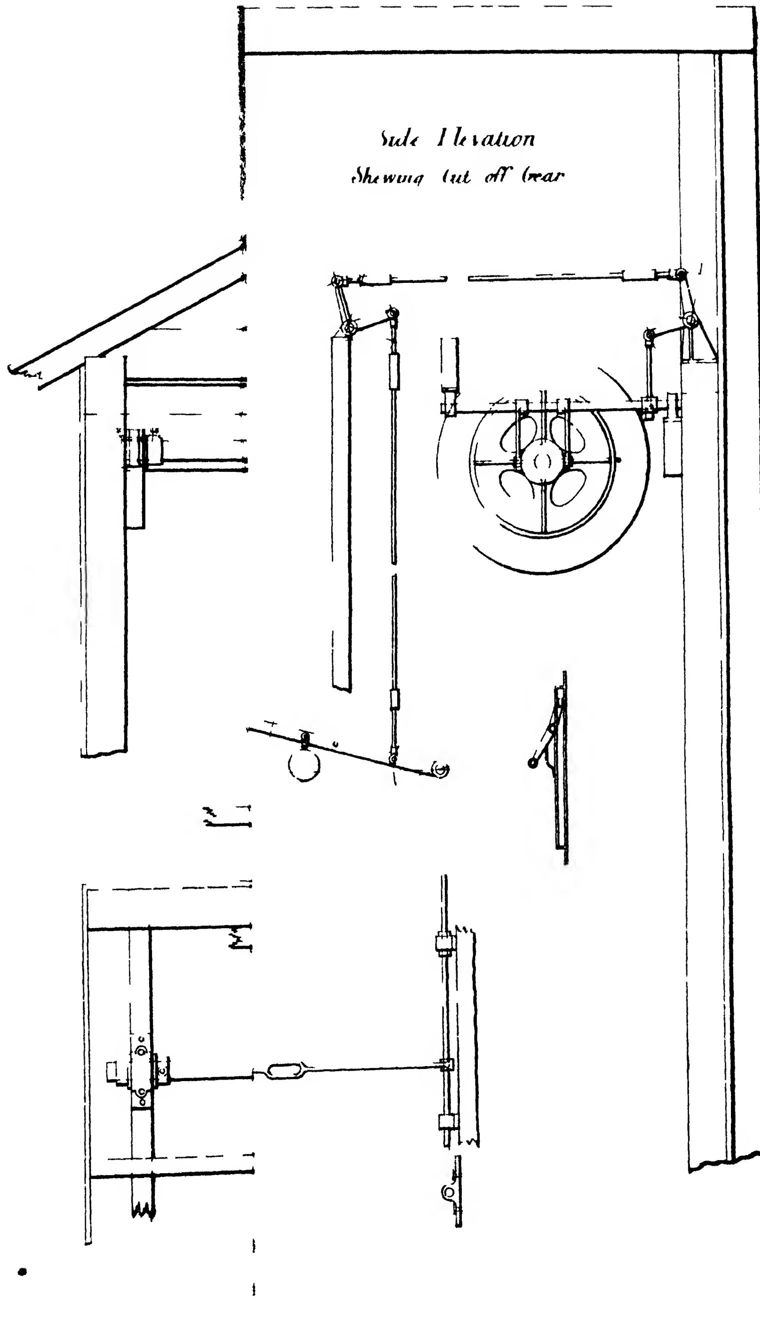


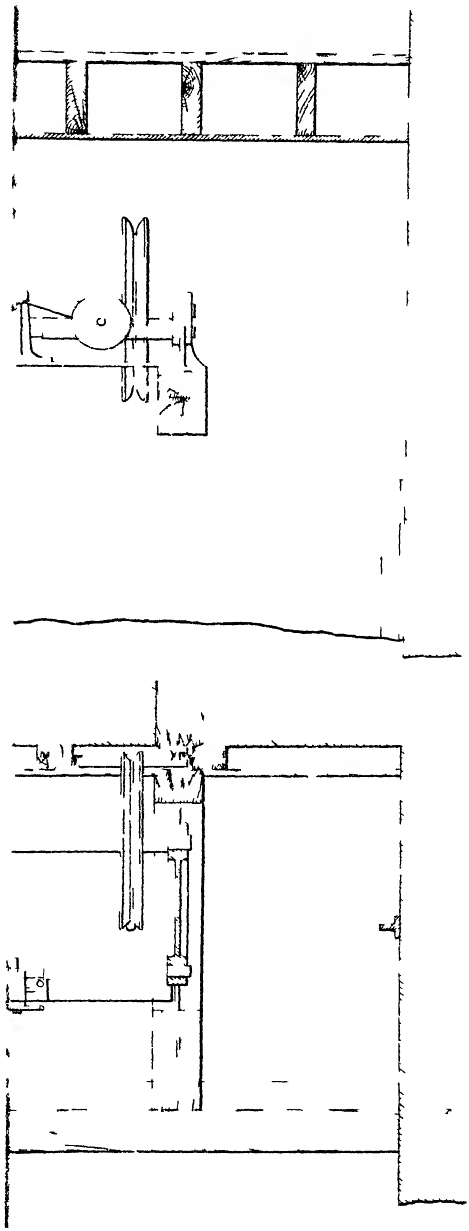
CEAR



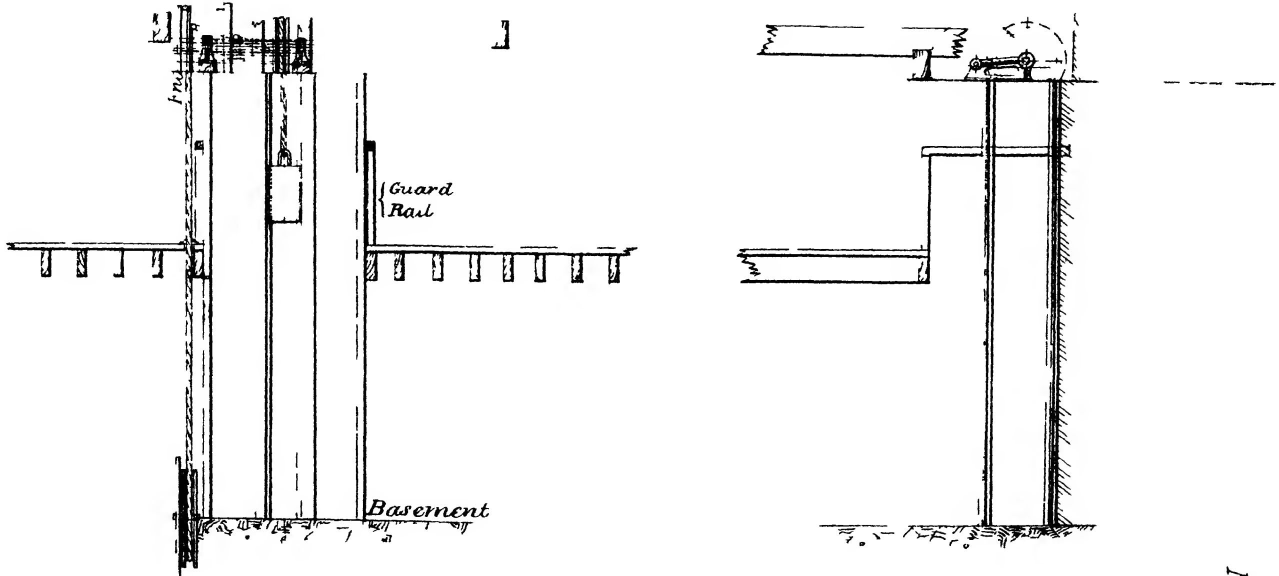



Side Elevation
Shewing Cut off Gear

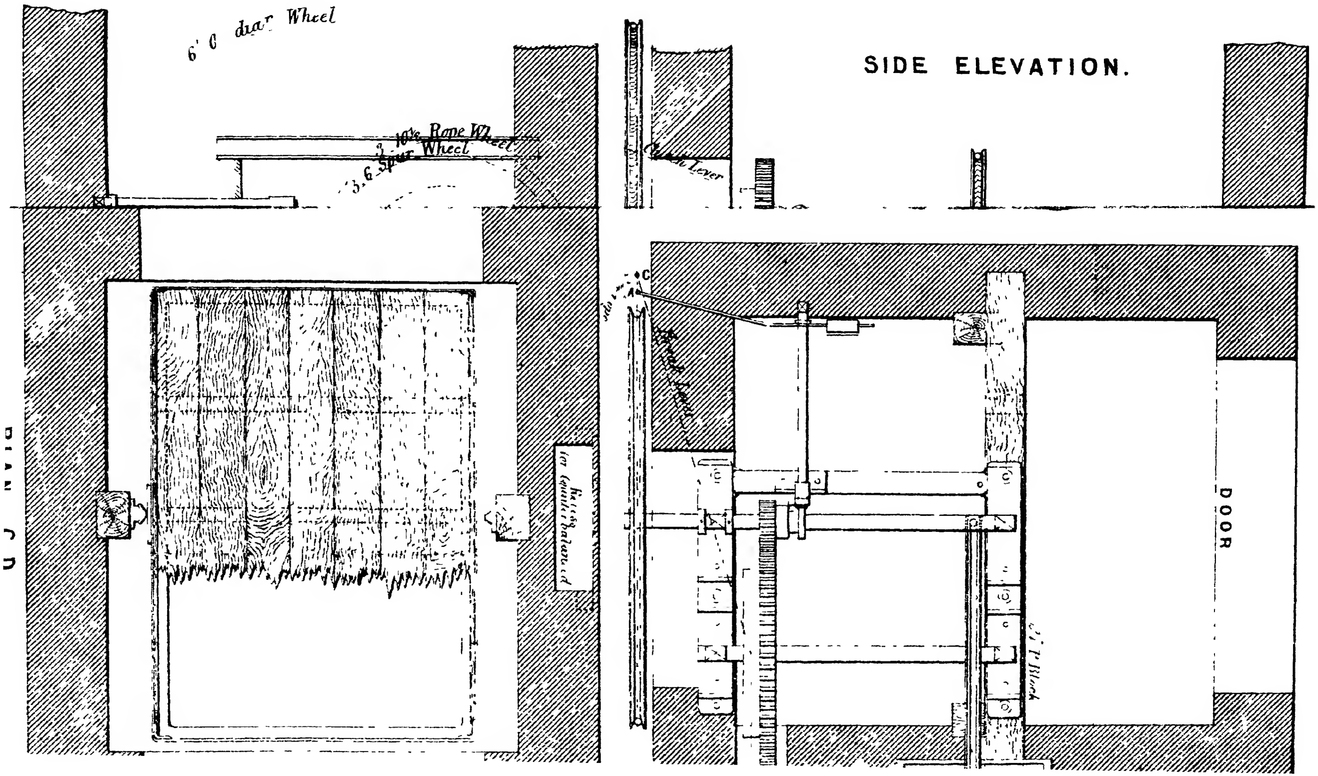
N° 47

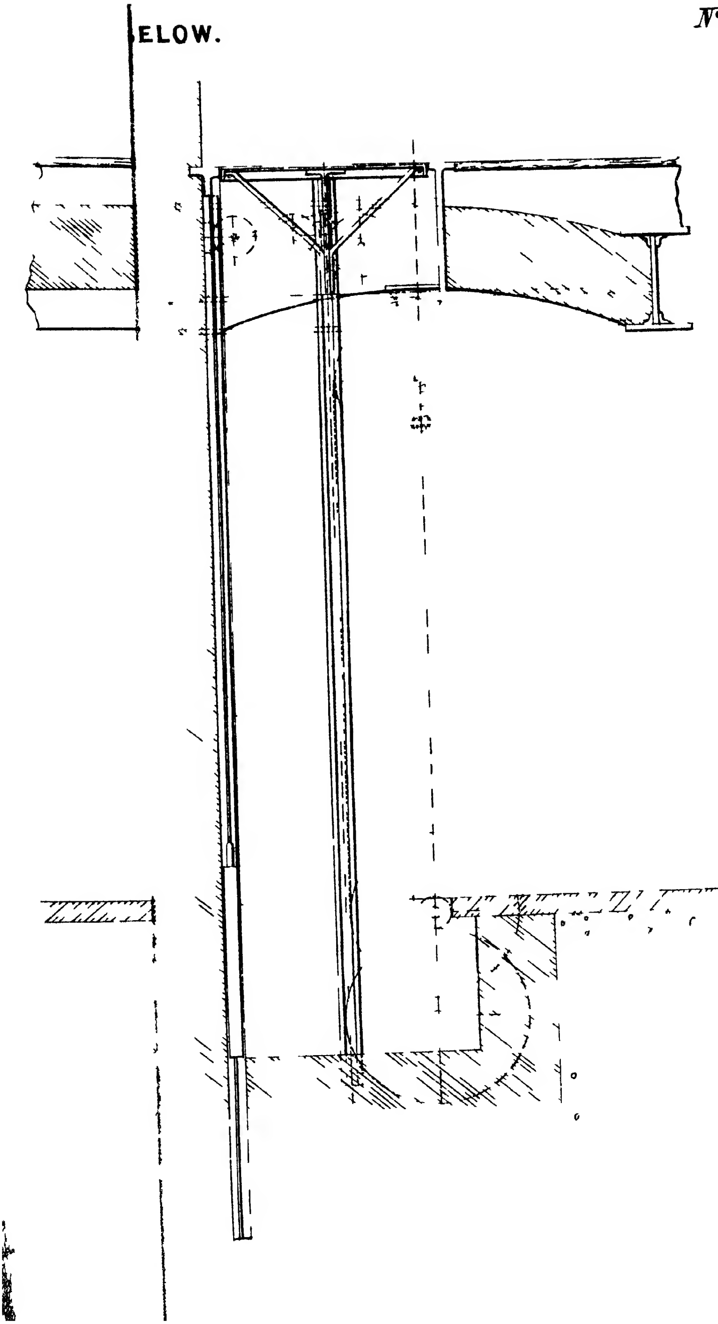


HAND POWER WAREHOUSE LIFT

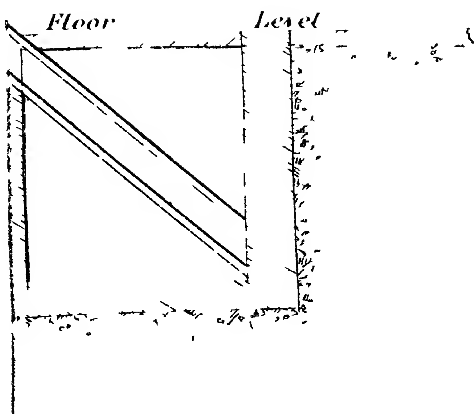


No 48

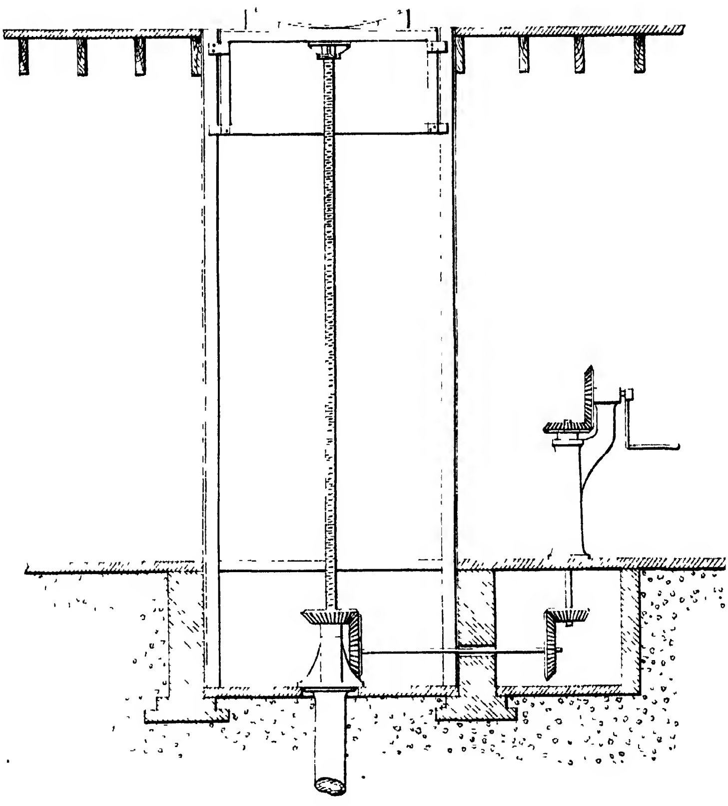

SIDE ELEVATION.
6' 0 diar Wheel
3' 10½ Rope Wheel
3' 6 Spur Wheel
Clutch Lever
Break Lever
Recess for Counterbalance
DOOR
C
A

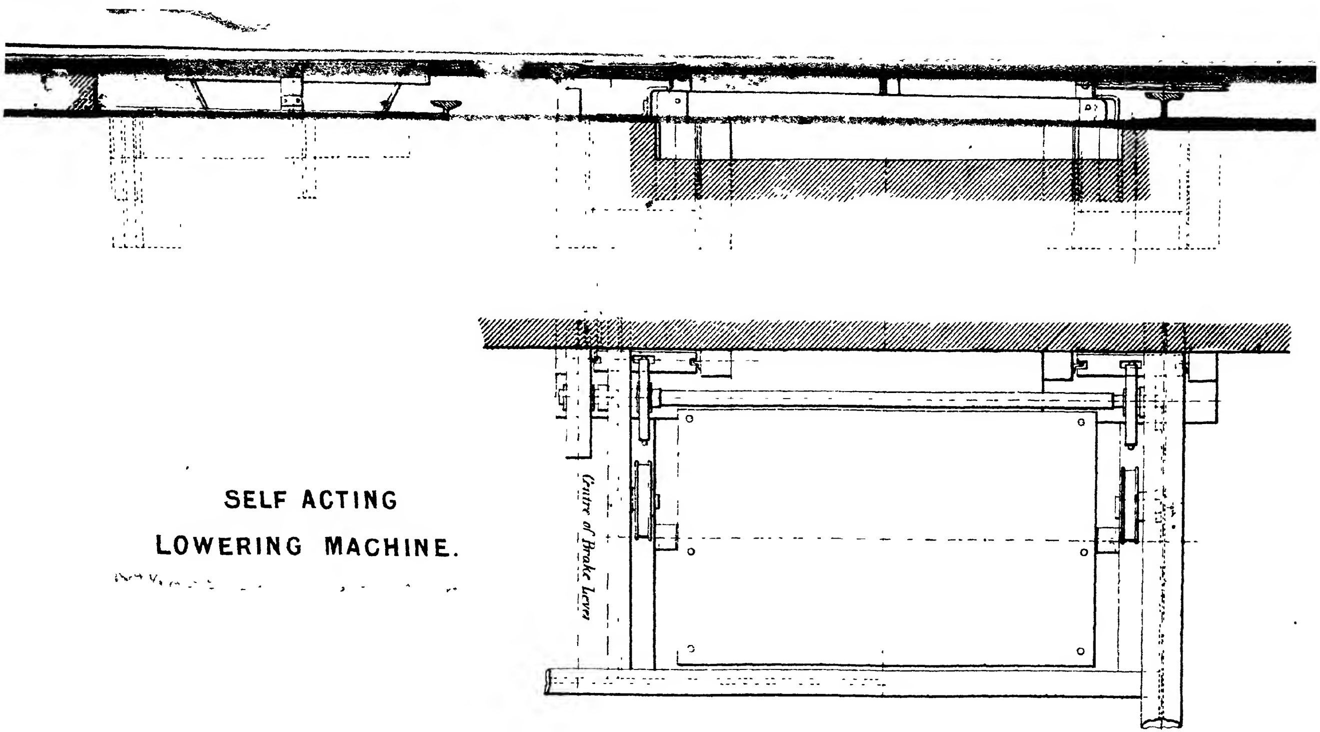

ELOW.

CELLARS.



Hand Power Screw Lift



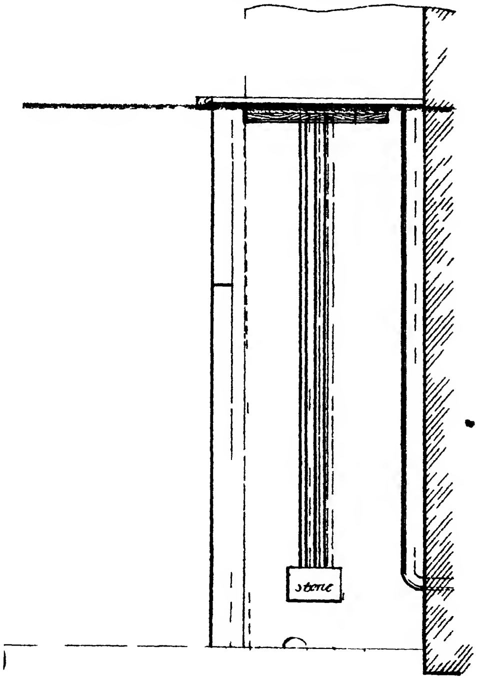


SELF ACTING
LOWERING MACHINE.

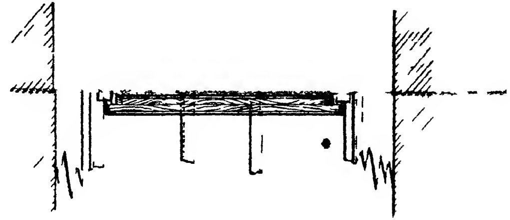
PLAN.

HAND POWER HOUSE LIFT

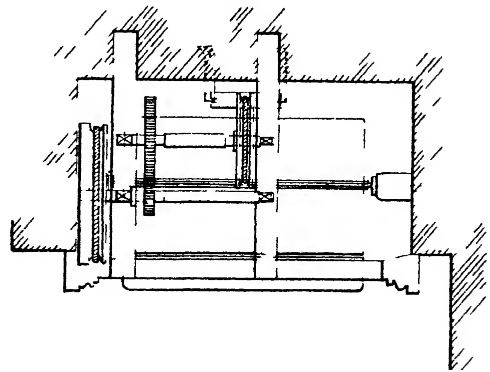
SIDE ELEVATION



FRONT ELEVATION

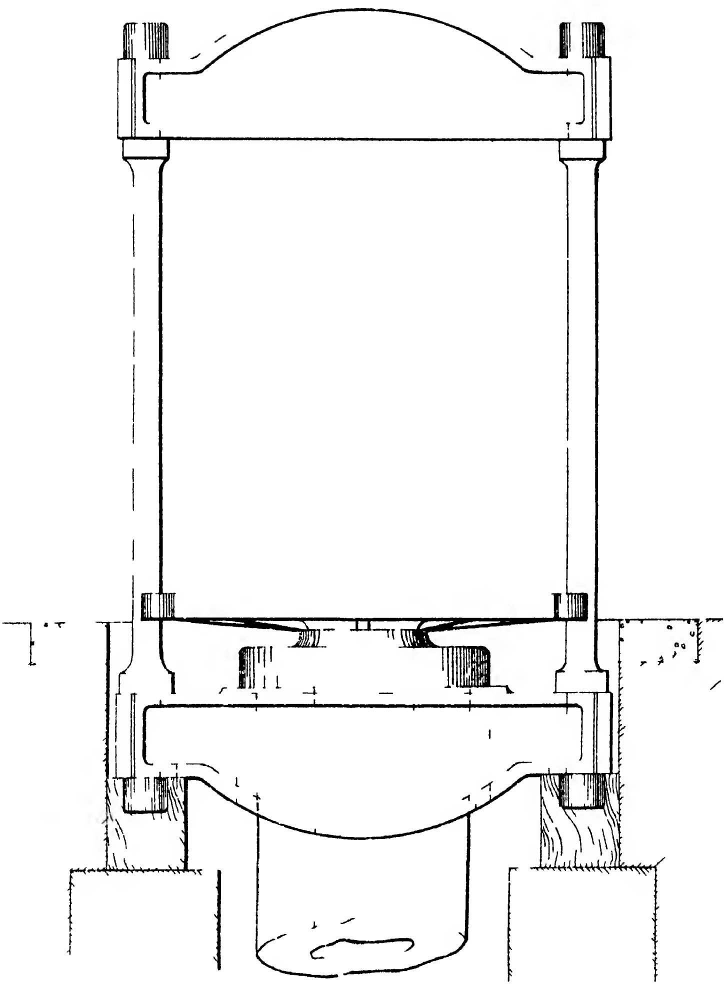


PLAN

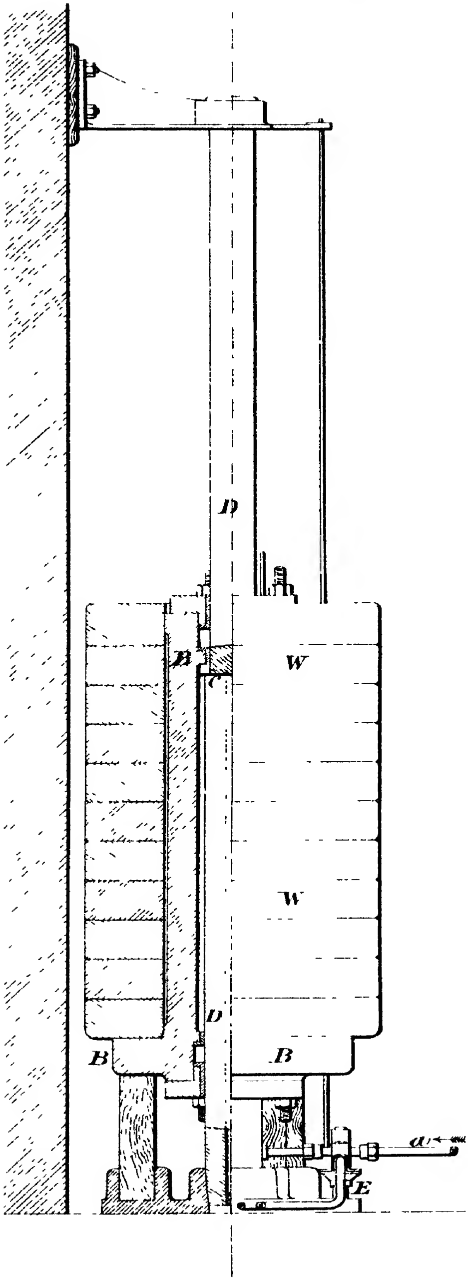


No. 5

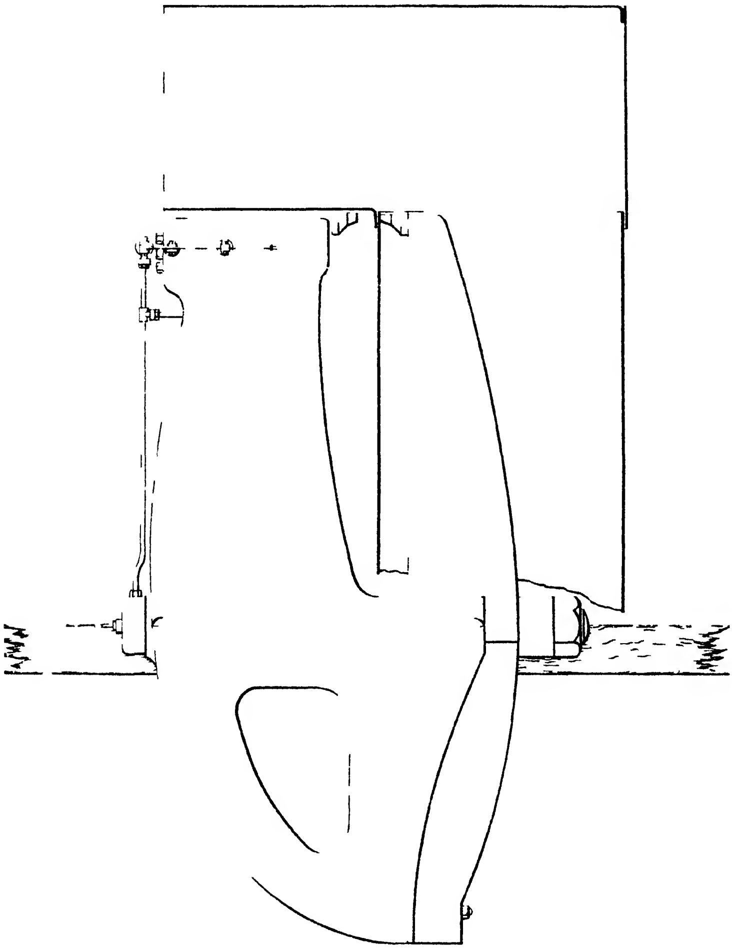
HYDRAULIC PRESS.



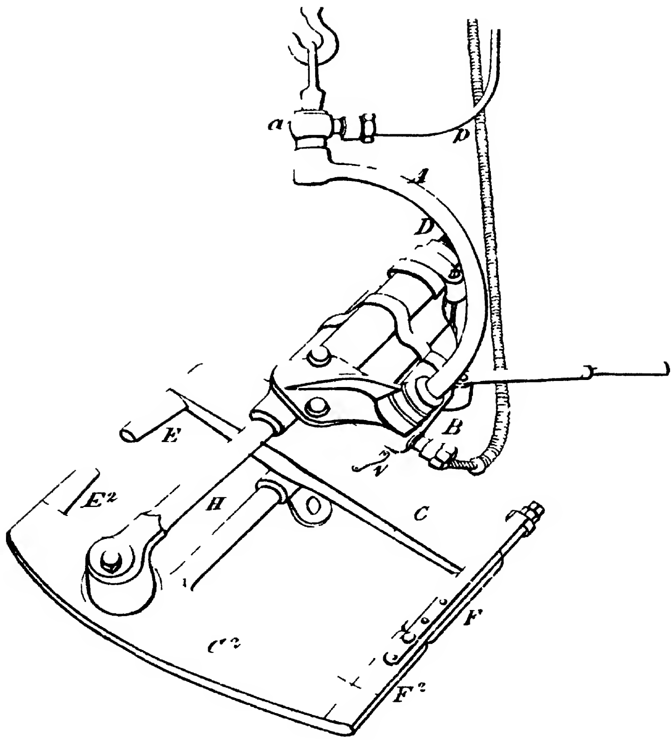
DIFFERENTIAL ACCUMULATOR.



STATIONARY HYDRAULIC RIVETTING MACHINE.



MACHINE.



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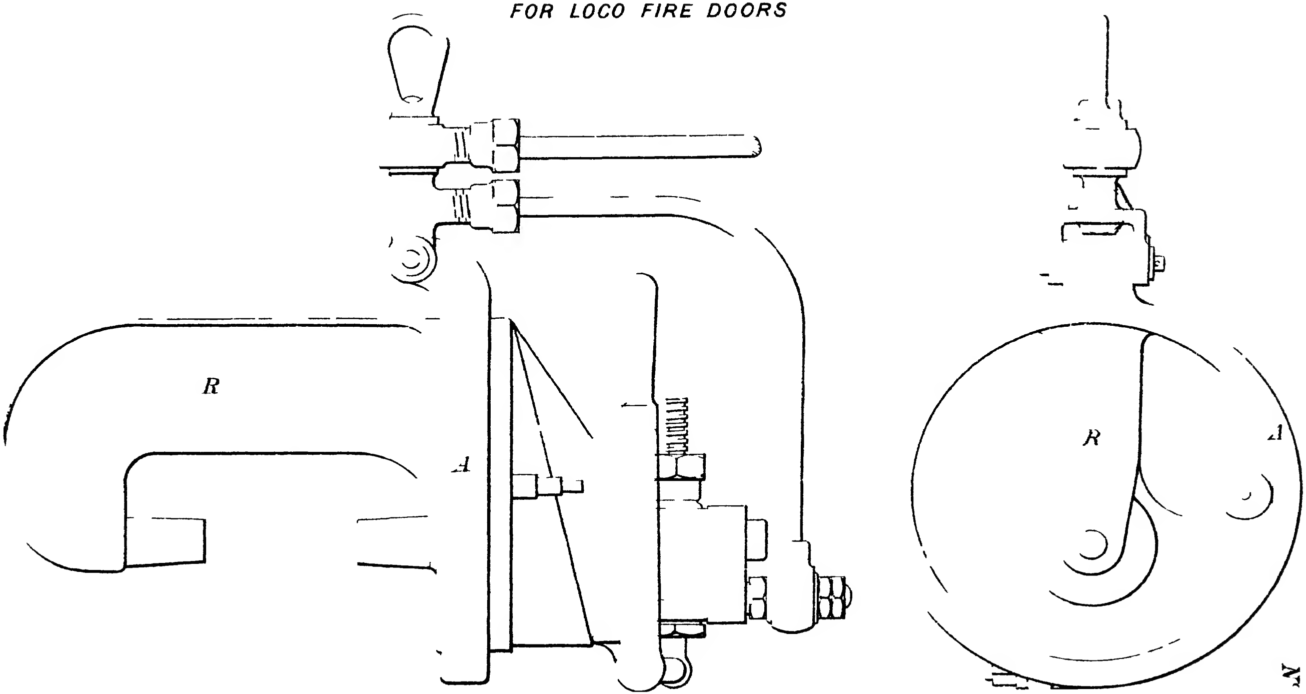

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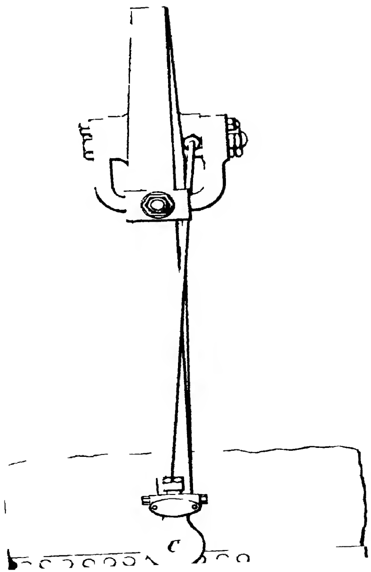

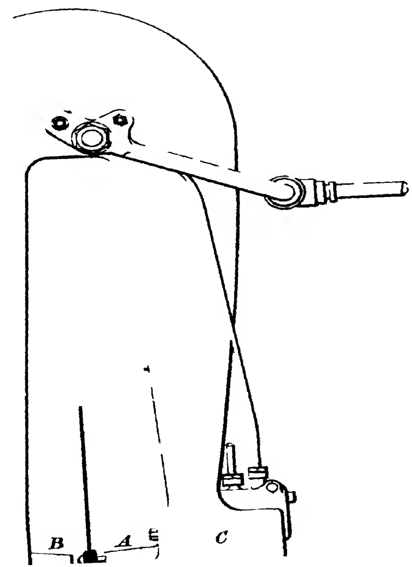

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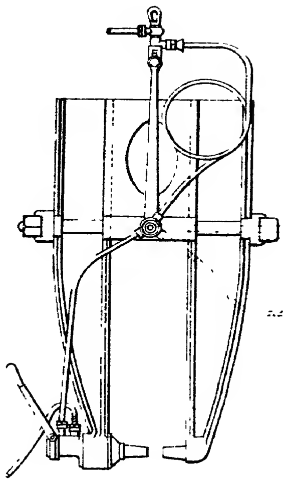

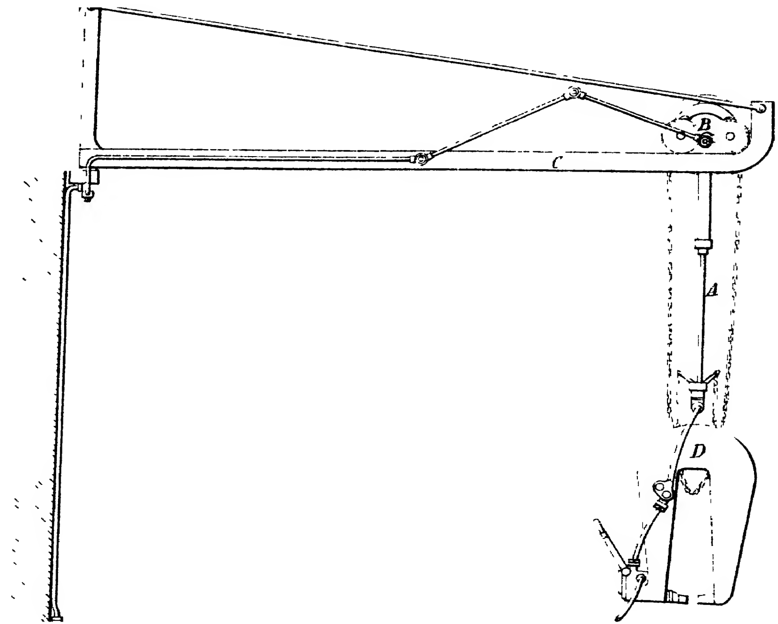

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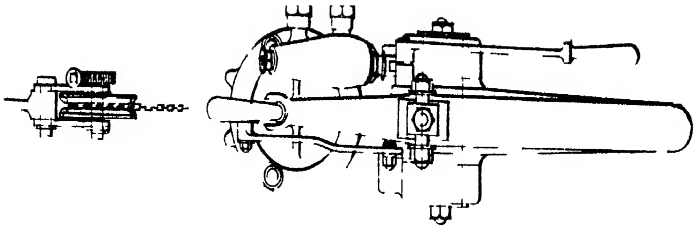

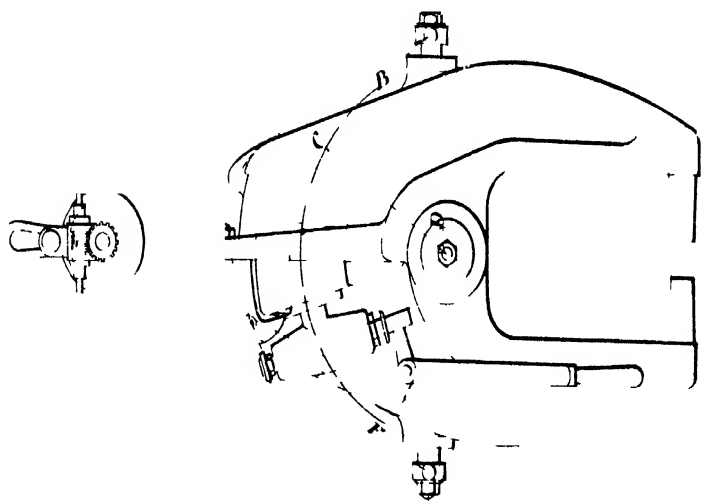

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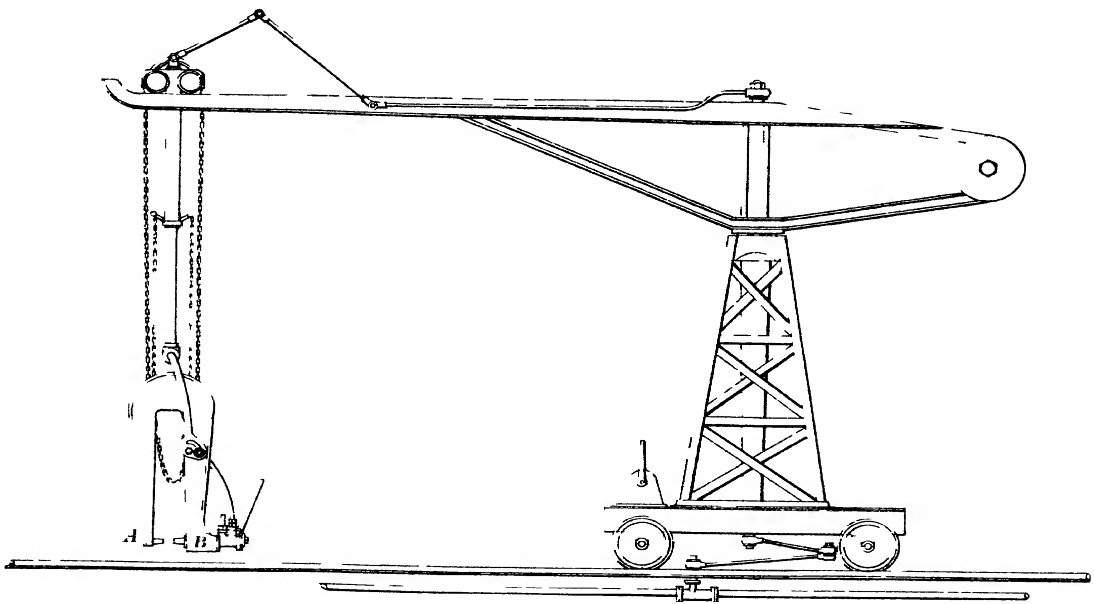

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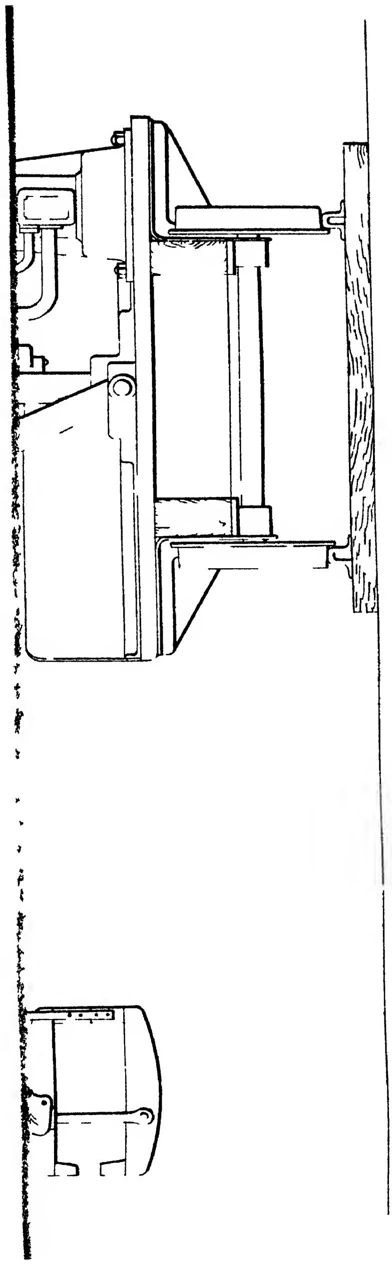

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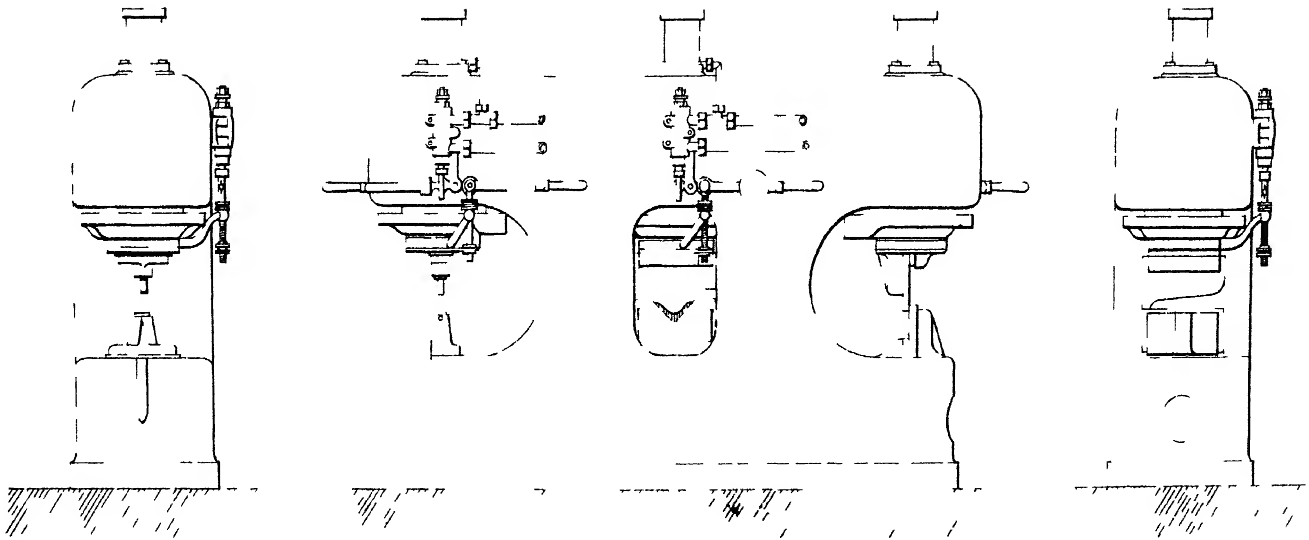

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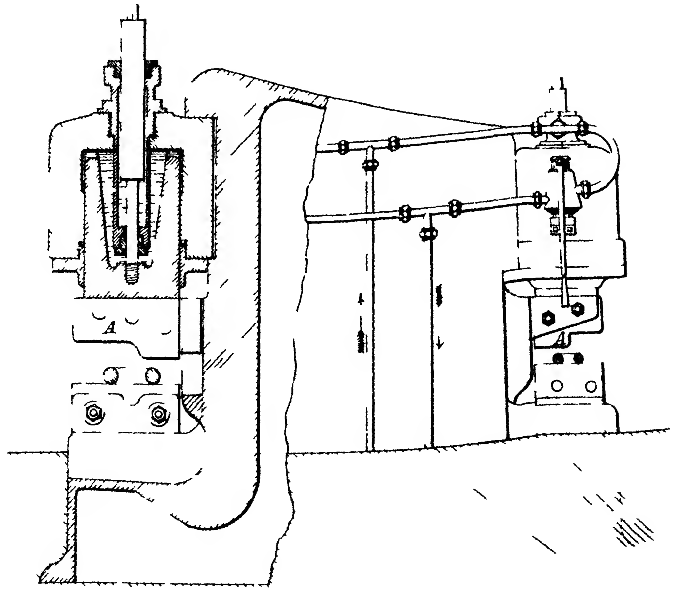

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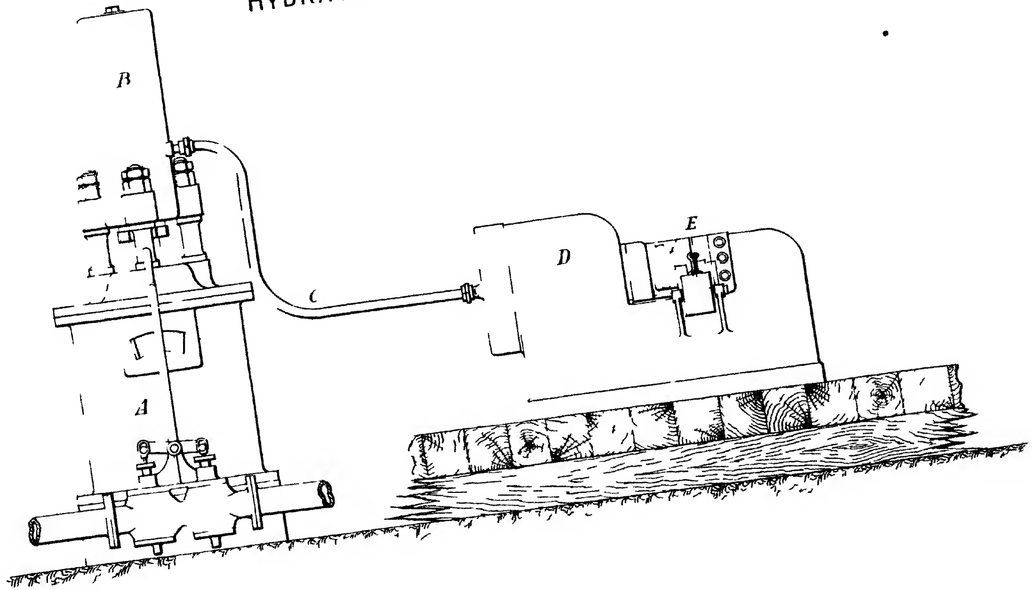

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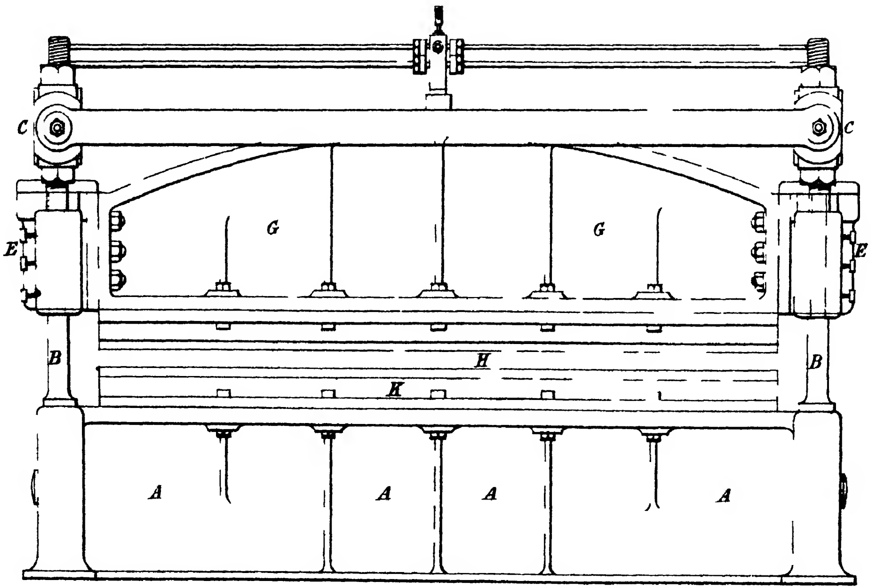

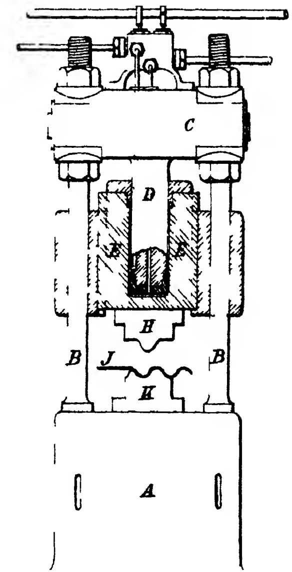

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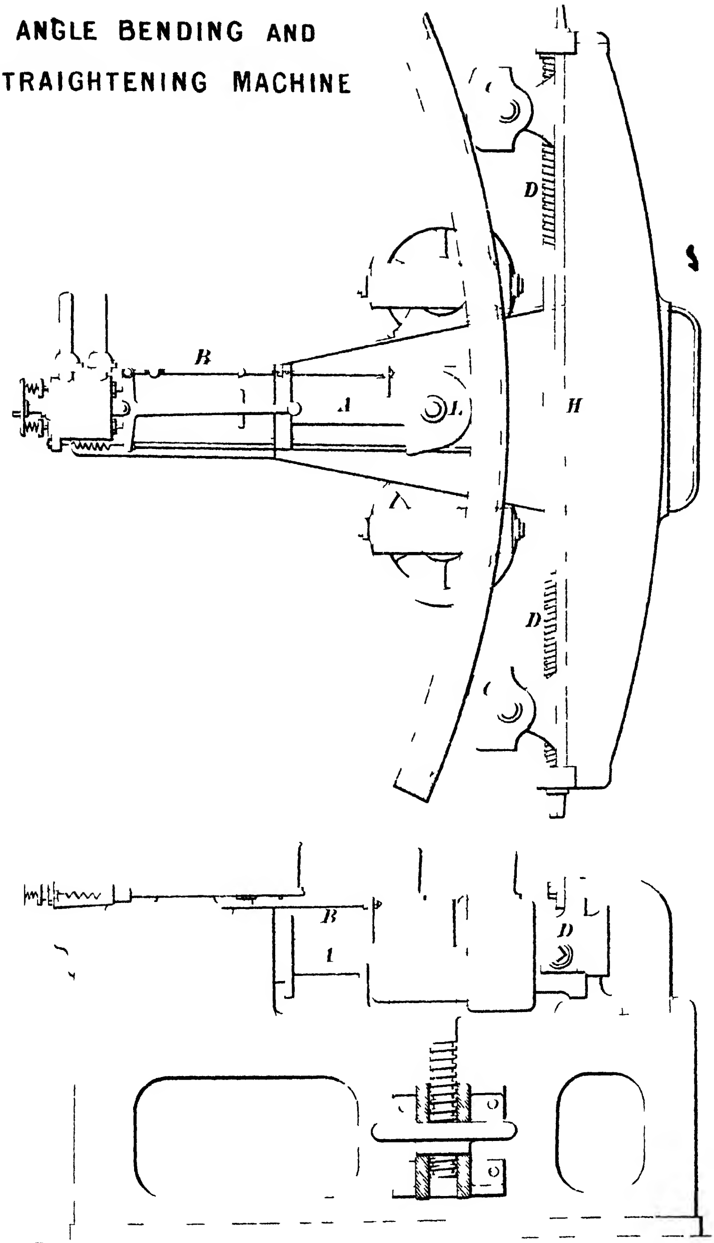

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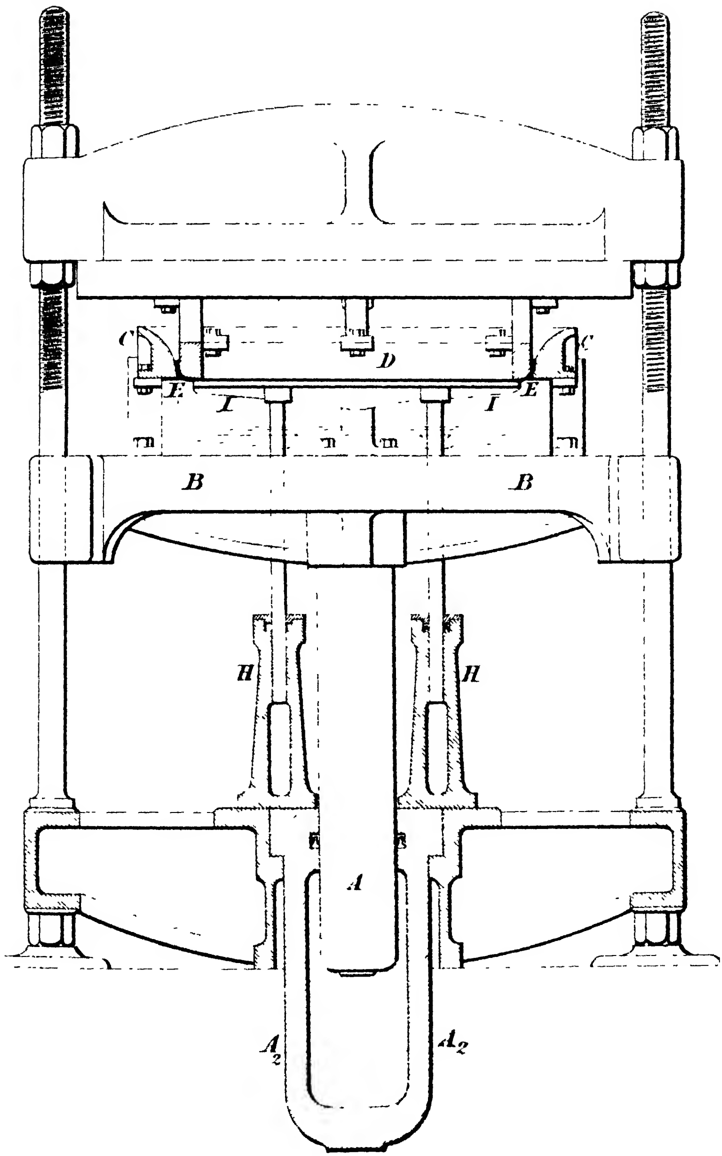

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